Energy Resource Development for the *West*

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Energy Resource Development for the West

PREPARED FOR

WESTERN INTERSTATE NUCLEAR BOARD

by
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JANUARY 1974

WESTERN INTERSTATE NUCLEAR BOARD
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PREFACE

The 1967 Western Governors Conference proposed the formation of a Western Interstate Nuclear Compact and Board to foster the commercial and industrial progress of the West through the proper employment of scientific and technological advances in the nuclear field. The compact, adopted by the required number of eligible States in 1969, is designed to maximize the benefits to nuclear resources, facilities, and skills through the cooperative efforts of the western states. In its four years of existence, the Western Interstate Nuclear Board has conducted programs and projects on a variety of nuclear issues that affect the member states such as nuclear plant siting, mutual radiological assistance, radioactive waste management, etc.

Over the past two years, WINB has been drawn increasingly into discussions concerning the Western Region's overall energy problems as well as those related primarily to atomic energy. This was perhaps a natural occurrence as WINB is the only state-supported regional agency in the West working in energy-related fields. Following the adoption of a resolution by the Western Conference, Council of State Governments in November 1972 calling for region-wide energy studies, and a decision by WINB that a better understanding of the Region's overall energy situation was needed by the Board in making recommendations to the member States in the nuclear field, WINB established an energy Committee to conduct a regional survey of energy resources, demands, consumption, and related topics. The WINB Energy Committee commissioned a study by an independent consultant, Lawrence E. Wilkinson, in mid-1973.

This report contains the principal findings and conclusions of the WINB Energy Committee's study. Contemporary and potential energy resources have been examined and analyzed in three timeframes. This report shows an increasing need for the Western States to support accelerated planning and development programs in several energy-related fields in order to achieve economic progress consistent with environmental quality.

This document is submitted to the Governors, state government officials, and other regional leaders with the hope that it will be helpful in planning and policy development in the energy field.

Paul Clifton
Chairman
Committee on Energy
Western Interstate Nuclear Board

January, 1974

Acknowledgment

The author is indebted to the Energy Committee of the Western Interstate Nuclear Board for its guidance and critical comments and especially for sharing its observations on how the energy resource development opportunities vary within the various sub-regions of the West. The members that make up the energy committee include:

Chairman: Paul Clifton, Resources Agency, California (WINB member)

H. A. Boucher, Lt. Governor, Alaska (WINB member)

Noel Clark, Nevada Public Service Commission

Tom Ten Eyck, Colorado Department of Natural Resources (WINB member)

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1.0 INTRODUCTION

The West has a great diversity of energy sources available to it. The decisions for tapping these energy sources have proceeded at a relaxed pace in past decades but the tempo has quickened in recent months. The many delays in finding new sources of petroleum products, added refinery capacity and the construction of new electrical generation capability throughout the nation has permitted common problems such as low rainfall and oil imports to create crises throughout the nation. As a consequence, a new energy pattern is developing for the United States. The energy sources of the West will be entwined into the new national pattern which will result in both new commerce and new environmental impact for several of the western states.

This report examines the total energy production and consumption of the Western States for the calender year of 1971 with emphasis on the electrical generation needs of the West. The result is a December 1973 examination of how the western states can assist in developing a new national energy pattern and become a net exporter with respect to energy in certain forms. Not included in the energy balance is the energy invested in products shipped into the region or the energy in the uranium shipped out of the West.

The report addresses itself to three time-frames:

Near-term --- through 1974
Transitional --- through 1985
Long-term --- 1986 to 2000

In order to meet our economic and personal needs, a variety of fuels will be considered in future years. The choice of fuels in the near-term is most likely to be based more upon availability than upon economics. In the future, higher costs of energy, in all forms, will encourage the development and production of energy sources that have heretofore been considered uneconomic. The duration of the transitional period will depend, in part, on the rate at which regulatory agencies can examine the environmental impact of each new energy source. Even though the United States can intensify depletion of oil and gas reserves to be more nearly self-sufficient with respect to energy by 1980 a stable energy economy can probably not be expected much before 1985. Even though 1985 has been selected as the end of the transitional period the nation's interest would best be served by establishing long-term stability before 1985. Tracking the rate of progress over the past three years in licensing nuclear plants and in geothermal and oil shale leasing is the basis for not being optimistic about a stable energy economy before 1985.

By 1985, it is expected that about 15 percent more of our energy consumption will be in the form of electrical power. To meet this need an even stronger nuclear energy program than has been previously forecast will be required and must begin immediately. This need, together with the development of other potential energy resources is discussed in the report.

The public must appreciate the fact that the capital cost of nuclear plants, as well as fossil fired generating plants, is high and that the time required to put a nuclear plant "on-line" is currently ten or more years from the time of decision to proceed due to the many licensing and scheduling requirements. Not to be overlooked is the need for the utilities to raise enormous sums of capital for new generating plants. Utilities have generally decided to proceed with nuclear plants which is an indication that for the next 30 years uranium will be a reliable and economic fuel for base load plants. Each delay in the construction of nuclear plants creates a larger financing problem as construction costs continue to escalate and, of course, will result in a continued deficit in meeting electrical energy needs. Recognizing these problems the USAEC[1] has indicated that top priority will be given to reducing the licensing time to six years.

Resource management of fuels other than nuclear is discussed to create an awareness that some are no longer plausible for electrical generation and can by used for more critical applications (e.g. petrochemicals, transportation, pollution control systems). Accelerated use of coal for electrical generation and as feedstock for gasification and liquefaction is an essential part of a changing energy program.

Energy is not just a governors' or elected officials' problem. It is everyone's problem and even with mandatory allocations, the citizens of the western states and the rest of the nation will need to take part in an energy conservation program until a stable energy economy is achieved including optimal use of nuclear power.

2.0 SUMMARY AND CONCLUSIONS

This report surveys the energy demands and resources of the West and examines the ability of the West to meet not only its own needs but to assist the nation in becoming independent of foreign energy imports during the next ten to twenty years. It is found that great disparity exists among the Western states with respect to meeting their individual energy needs but that as a region the West is currently only about 10 percent deficient in meeting its own needs. With the national emphasis towards energy independence, the West should expect to be called upon to become a net exporter of energy. The great coal and oil shale deposits in the Rocky Mountains and the petroleum deposits in Alaska should provide a basis for energy export from the region when they are developed. Meanwhile the growing energy demands of the West will need to be met by construction of more thermal power plants within the region and with a serious energy conservation program. The extent of the growing energy demands has not been accurately determined. Such a determination may not be possible until the West becomes accustomed to the fact that energy is no longer an unlimited commodity.

---

[1] Statement by W. O. Doub, AEC Commissioner to national governors on Dec. 13, 1973, Washington, D.C.

A basis for this study, 1970 Federal Power Commission energy projections have been used. The study has then examined how prepared the West is for meeting such a rapid growth rate. It is found that the West is already without adequate reserve margins and that growth rate will probably be resource limited until after 1980. Furthermore, it has become apparent that interstate cooperation and energy conservation throughout the West is essential to avoid a serious economic problem in some of the more populated regions of the West. To liberate some of the energy resources that are indigenous to the West a combination of technological and social progress will need to be made. Some of the technological needs and some of their costs are described in Section 4.2. Social acceptance for expanding the energy base in the West using existing technology is equally important but beyond the scope of this study.

Energy planners have been limited in their ability to cope with the time schedules for public review. The study reveals the extent to which nuclear power plant construction has lagged behind the 1970 Federal Power Commission projection. With needed streamlining of public review and licensing procedures the necessary nuclear construction can be restored by 1990 and possibly before. Meanwhile it has become apparent that the West should be prepared to burn more coal than projected to protect the endangered reserve margins in the electrical grids.

Perhaps the greatest contribution of this study is an identification of the extent to which each state can contribute or distract from the energy balance in the West. Currently, there are only four states in the West that are net exporters or producer states. These same states will probably be called upon to assist the nation in becoming energy independent. The consumer states in the West will need to share a greater role in helping the West and the nation to become self-sufficient. This can be done with existing technology using nuclear power plants and increased conservation. Assistance of all states in supporting the four point program below can assist in developing the available and emerging energy resources.

There are ways for the West to become self-sufficient with respect to energy and to support the concept of national energy independence. This study concludes that it will be neither quick nor inexpensive and should include much of the following four-point program.

I. Increase energy resource development by the following means:
   1. Construction of more coal-fired electrical generating plants.
   2. Construction of more nuclear electrical generating plants.
   3. Installation of more peaking turbines on federal dams.
   4. Continued exploration and recovery of domestic oil and natural gas reserves.

II. Concurrent with the above construction program an effort towards resource conservation must be implemented. This should include:
   1. Public education on improving efficiency of energy use.
   2. Rate payer incentives.
   3. Utilization of heated effluents.
   4. Requests for voluntary reductions when essential.
   5. **Provisions for mandatory reductions when essential.**

III. Accelerate efforts to relieve the drain of our dwindling oil and gas resources in the lower 48 states by:
   1. Finding ways of sending Alaskan energy south, such as:
      a. Creation of deepwater ports to accept LNG tankers,
      b. Installation of energy intensive industries in Alaska,
      c. Installing gas and oil pipelines to reach Alaskan ports.
   2. Accelerate geothermal power utilization by urging the Department of Interior to start leasing federal lands for exploration and development.

IV. Encourage research and development of potential new energy resources. These include:
   1. Coal gasification.
   2. Recovery of oil from shale.
   3. Breeder reactors.
   4. Solar energy.
   5. Fusion.

3.0 ENERGY DEMANDS OF THE WEST

The Western Interstate Nuclear Board is represented by the following states.

- Alaska
- Arizona
- California
- Colorado
- Idaho
- Montana
- Nevada
- New Mexico
- Oregon
- Utah
- Washington
- Wyoming

2 Dakota
Neb
Hawaii

Collectively, the member states cover 49 percent of the territory in the U.S.A. and represent 17 percent of the population. Energy sources among the member states vary widely, although collectively the energy production and consumption is similar to the total nation.

Several forecasters have predicted the energy requirements of the U.S.A. to 1985 and 2000. In December 1972, the National Petroleum Council (NPC) issued a projection[2] for both a "high case" and "low case" for United States energy demands from 1985 to the year 2000. Most of the recent forecasts [3,4,5] have fallen within the NPC "high" and "low" cases. If one were to take 15.3 percent of the NPC "high and "low" cases for 1985 and 1990 these points would bracket the 1970 FPC projection for energy to be consumed in the West, as shown in Figure 1. Since the West consumed more than 15.3 percent of the U.S. energy consumption in 1970, the use of a 15.3 percent factor accomodates some energy consumption leveling that is taking place nationally. The second curve in Figure 1 is projected demand for electrical power. Electrical loads are expected to follow a growth rate at even a steeper slope than total energy to compensate for the observed trend towards greater use of cleaner forms of energy. The 1970 National Power Survey[6] projected an increasing use of electrical power to a point where over one-half of the energy consumption in the West is expected to be electrical by 1990. An extrapolation of the trend toward electrical energy is shown in Figure 1 and Figure 2. Whereas, electrical power generation systems can meet only about 30 percent of our energy demands today, over 50 percent of our energy needs are expected to be electrical with a more modern West in 1990.

The load centers in the West are somewhat discrete compared with the East Coast. The population trends, in recent years, suggests that the existing metropolitan areas will continue to be the focal points for the future growth in the West. These population centers are listed in Table 1 together with the corresponding projected load growth in 1980 and 1990.

To further examine the energy resources employed in the early '70's in the West Figure 3 shows that 17 percent of the U.S. population produced 7 percent of the coal; 23 percent of the oil; 11 percent of the natural gas; 66 percent of the hydroelectric generation and 16 percent of the installed nuclear power. This energy mix is transient in nature. Within availability constraints the mix is basically controlled by economics. The low cost hydroelectric power in the West is now a matter of only historical interest. California has been the most productive state in the West for the production of oil and gas but the production appears to have peaked about 1968 as shown in Figure 4. Without oil conservation efforts and offshore drilling California's ability to meet its own needs for oil is on a rapidly divergent path.

Except for Alaskan oil, the West's future energy mix for electrical production will have less hydro, less oil and less natural gas to work with as shown in Figure 5. Instead, electrical generation will need to rely upon coal, nuclear energy and any other reliable and economic source of energy. Projections on the amount of coal and nuclear power needed will depend upon the sustained demand for increasing amounts of electrical energy in the long term. For lack of better information the demand projections prepared for the Federal Power Commission are used in this study.

Availability of fuels for certain applications will also depend upon national energy policy decisions. For example, natural gas and oil has become subject to allocation to assure feedstock for the chemical industry and other critical uses. Some users of natural gas and oil have a variety of other choices. The best example is the electrical utilities which have been burning natural gas only because of the artificial economies brought about by federal regulation. As shown in Figure 6, the utilities could use any of five sources to generate the same kilowatt. As the natural resources of the nation are better marshalled it would appear that such non-renewable resources as petroleum products will be reserved for uses in which they have unique qualities. This may be done by either national energy policies or by a free market.

Figure 6 also shows that transportation in the West is strongly dependent on petroleum

---

[2] Report on U.S. Energy Outlook, National Petroleum Council, Dec. 1972.

[3] Shell Oil Company; The National Energy Outlook, March 1973.

[4] U.S. Department of Interior, Dec. 1972

[5] Report to Office of Science and Technology (AET-8) April 1972.

[6] U.S. Federal Power Commission, 1970.

Figure 1

TOTAL ENERGY USE AND TOTAL ELECTRICAL DEMAND PROJECTED FOR WESTERN U.S.

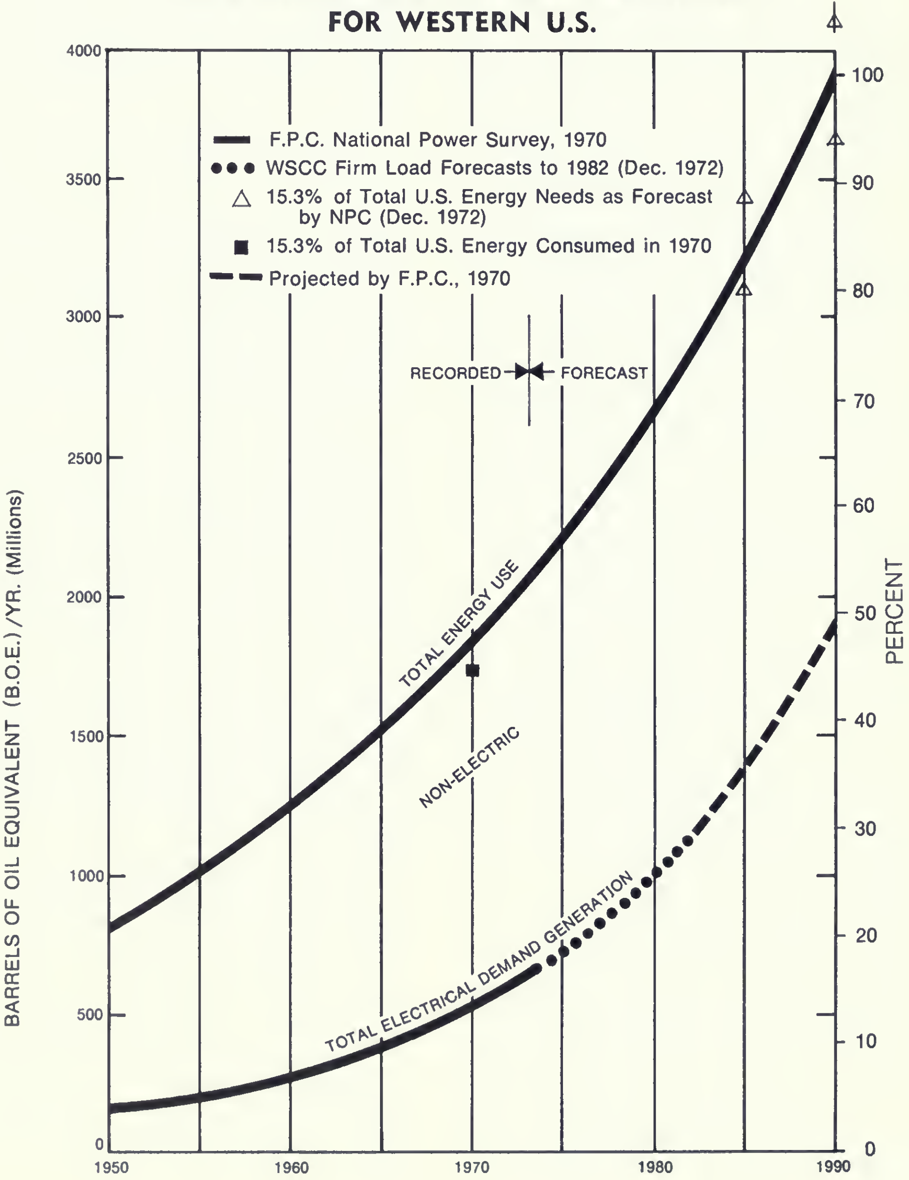
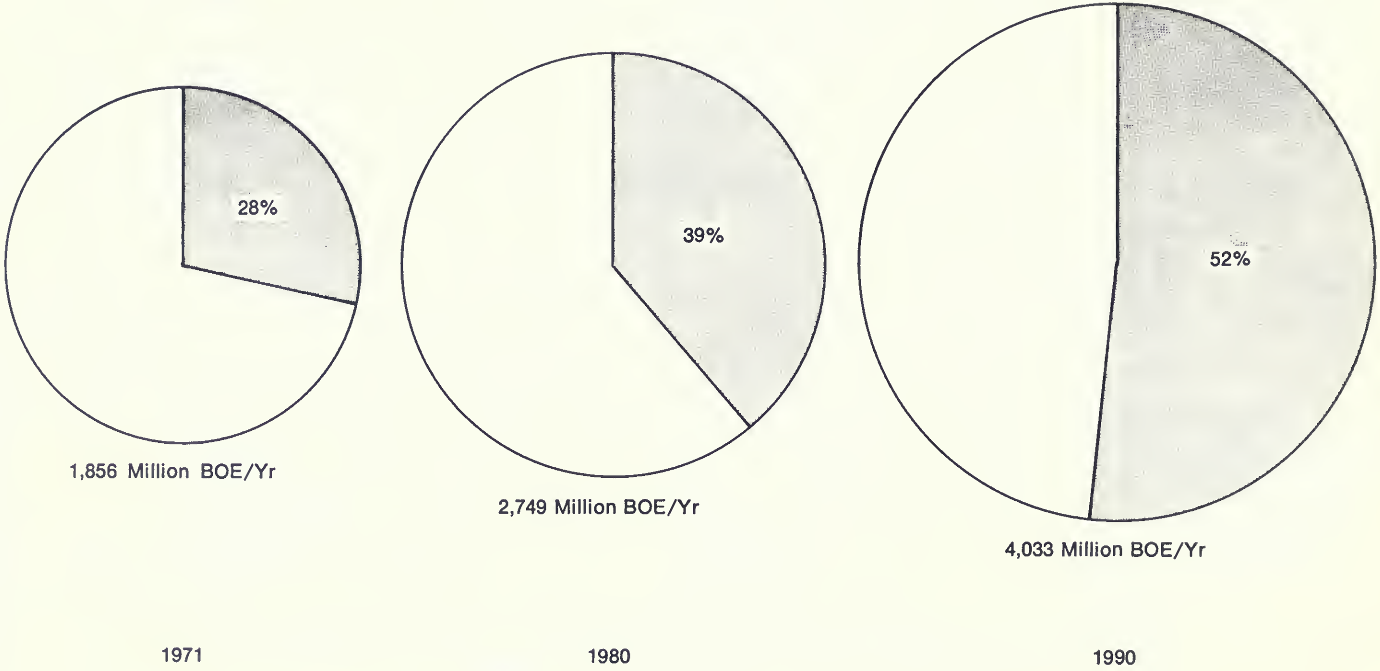


Figure 2

PROJECTED ELECTRICAL PORTION OF FUTURE ENERGY DEMANDS IN WINB MEMBER STATES



SOURCE: FPC 1970 National Power Survey

Figure 3

PORTIONS OF U.S. PRODUCTION FROM WINB MEMBER STATES – 1971

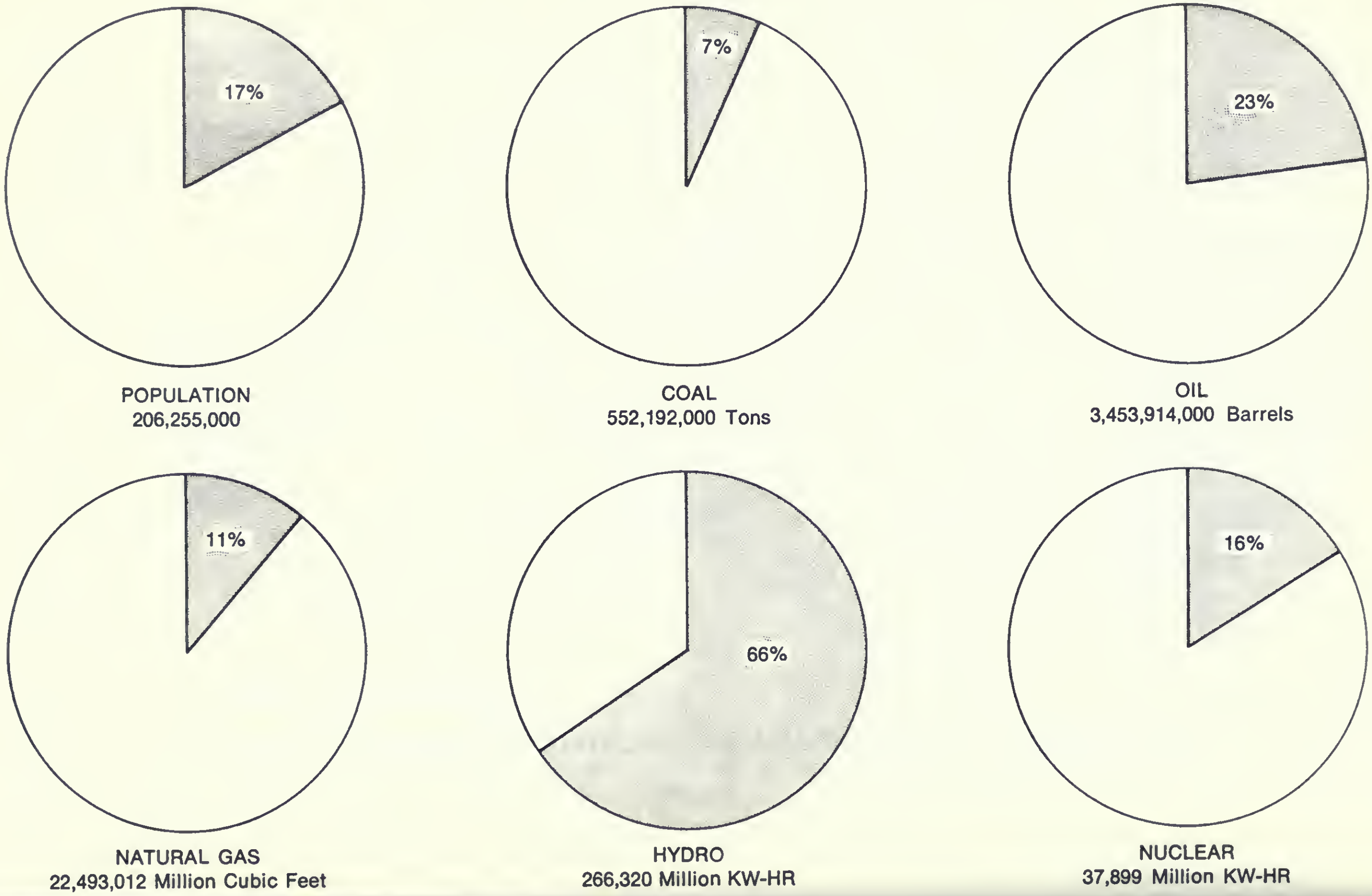
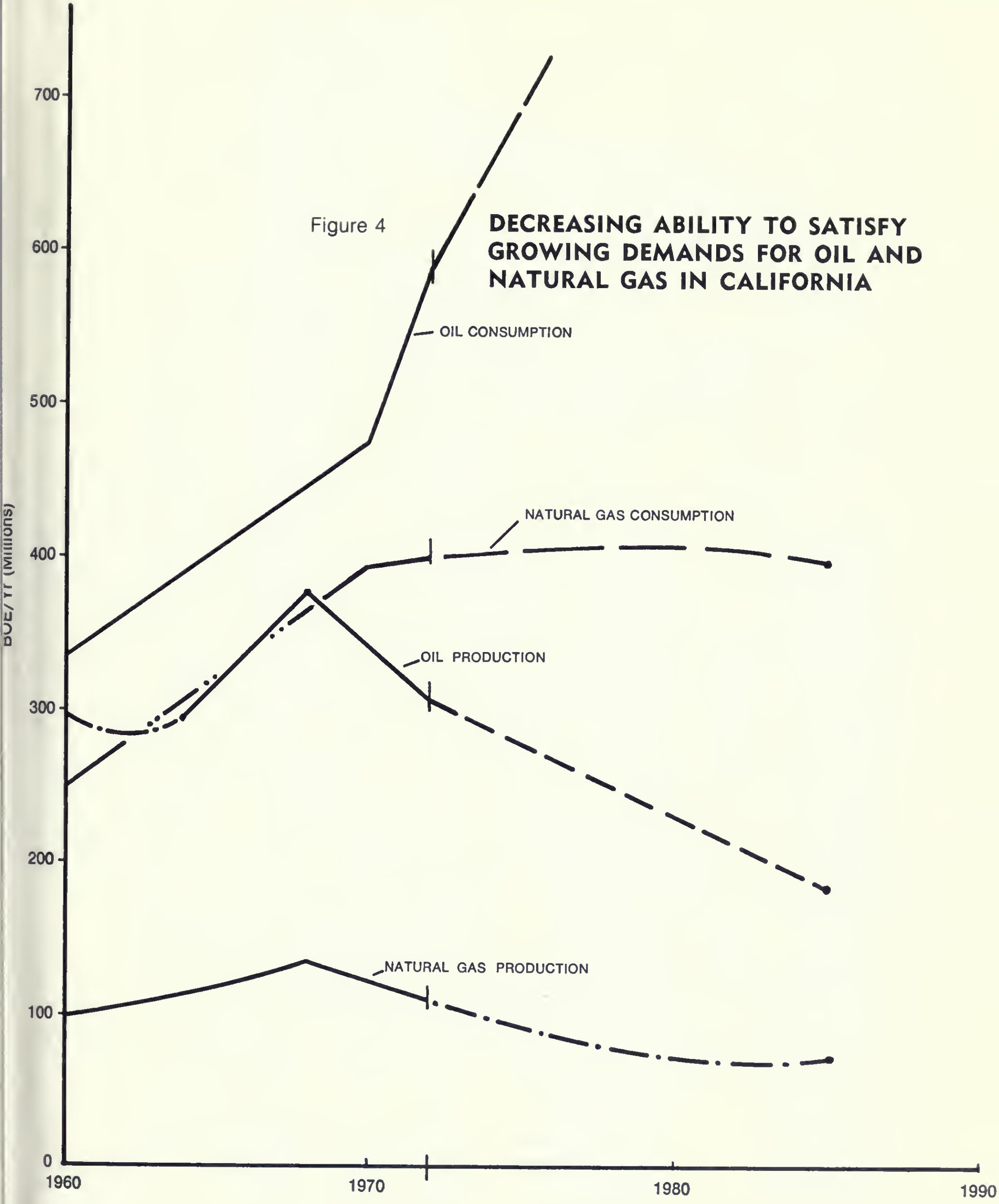


Figure 4

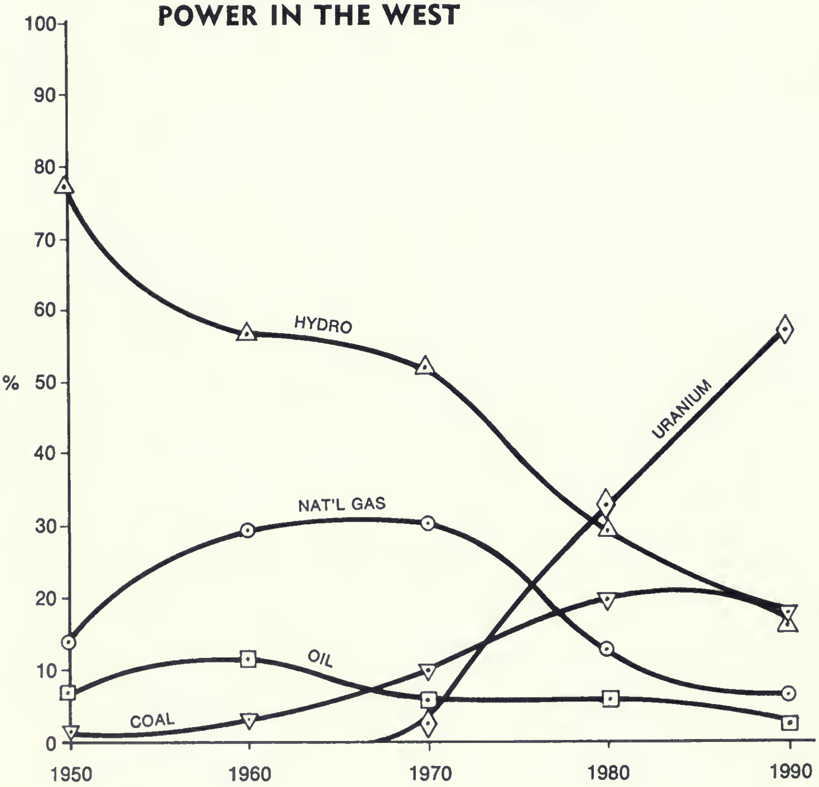
DECREASING ABILITY TO SATISFY GROWING DEMANDS FOR OIL AND NATURAL GAS IN CALIFORNIA



SOURCE: ENERGY IN CALIFORNIA, Resources Agency, State of Calif., Jan. 1973.

Figure 5

HISTORIC AND PROJECTED FUEL MIX FOR GENERATING ELECTRICAL POWER IN THE WEST

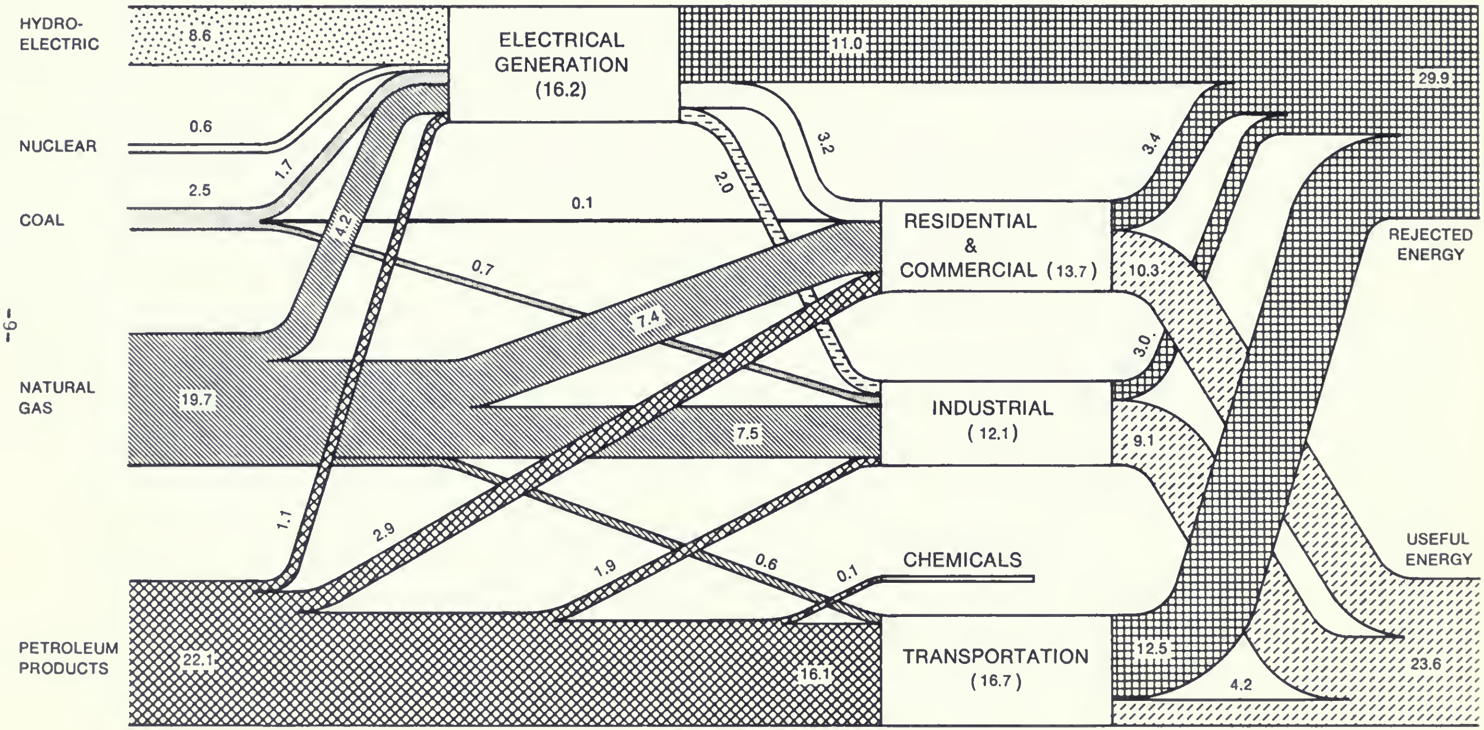


SOURCE: FPC 1970 National Power Survey Table 10

Figure 6

ENERGY UTILIZATION IN WESTERN STATES — 1971

(Barrels Oil Equivalent Per Person Annually)



products. With such an important function in the West and such a sizeable market it would appear that the incentive is strong to continue oil exploration both onshore and offshore. Oil and natural gas from Alaska will provide some relief sometime in the transitional period, after 1977. Additional exploration and drilling offshore could represent relief to declining domestic reserves by 1980.

To equate the energy that is available in different energy forms a unit of Barrels of Oil Equivalent (BOE) is used throughout the report. A BOE is equivalent to 5,800,000 British Thermal Units (BTU's) which makes it then equivalent to various quantities as shown in the glossary. In Figure 6 the electrical production shown as being from hydroelectric sources is represented as three times as many barrels of oil since thermal power generation is only about 33 percent as efficient as hydro power. Therefore, the waste heat from electrical generation is actually only about one-half of that shown. Other than this one difficulty, BOE is a tangible and convenient unit for energy planning.

Based on historic trends and continued favorable pricing it has been projected[7] that the fifty barrels of oil equivalent (BOE) consumed by the average Westerner in 1971 will increase to 68 BOE in 1980 and 86 BOE by 1990 as shown in Figure 7. Even though these consumption rates are expected to be less than the national average they would compound need for energy production in certain western states when the population grows at the rate predicted in Table 2.

To understand the energy production and consumption in the WINB member states, it is helpful to first compare the population (Figure 8). The state of California population is over seven times that of the average state and over 66 times as large as the smallest and obviously is the largest consumer in the West. Although California is also the largest energy producer in the West it is not self-sufficient and creates a deficit that affects the entire West.

---

[7] 1970 National Power Survey, Federal Power Commission, 1970.

Table 1

WEST REGIONS PEAK DEMAND BY LOAD CENTERS

(Megawatts)

Load Area	1970	1980	1990
Casper - Cheyenne - Cody	715 MW	1,570 MW	3,150 MW
Denver - Colorado Springs - Gr. Junction	2,130	4,230	8,030
Amarillo - Lubbock - Hobbs	1,790	3,480	6,380
Alburquerque - El Paso	1,035	2,180	4,090
Butte - Billings - Missoula	1,460	2,590	4,700
Boise - Pocatello - Salt Lake City	2,840	5,690	11,460
Spokane - Lewiston	2,190	2,950	3,750
Seattle - Tacoma - Olympia	5,760	11,730	32,580
Portland - Eugene - Medford	8,930	17,400	32,900
San Francisco - Sacramento - Reno	11,200	24,100	51,600
Los Angeles - San Diego - San Bernadino	13,300	27,700	55,000
Phoenix - Tucson - Las Vegas	4,490	9,520	20,600
Total	55,840MW	113,140MW	234,240MW

Reference: F.P.C. 1970 National Power Survey, Part III, 1970

Figure 7

TOTAL ENERGY DEMANDS IN WINB MEMBER STATES

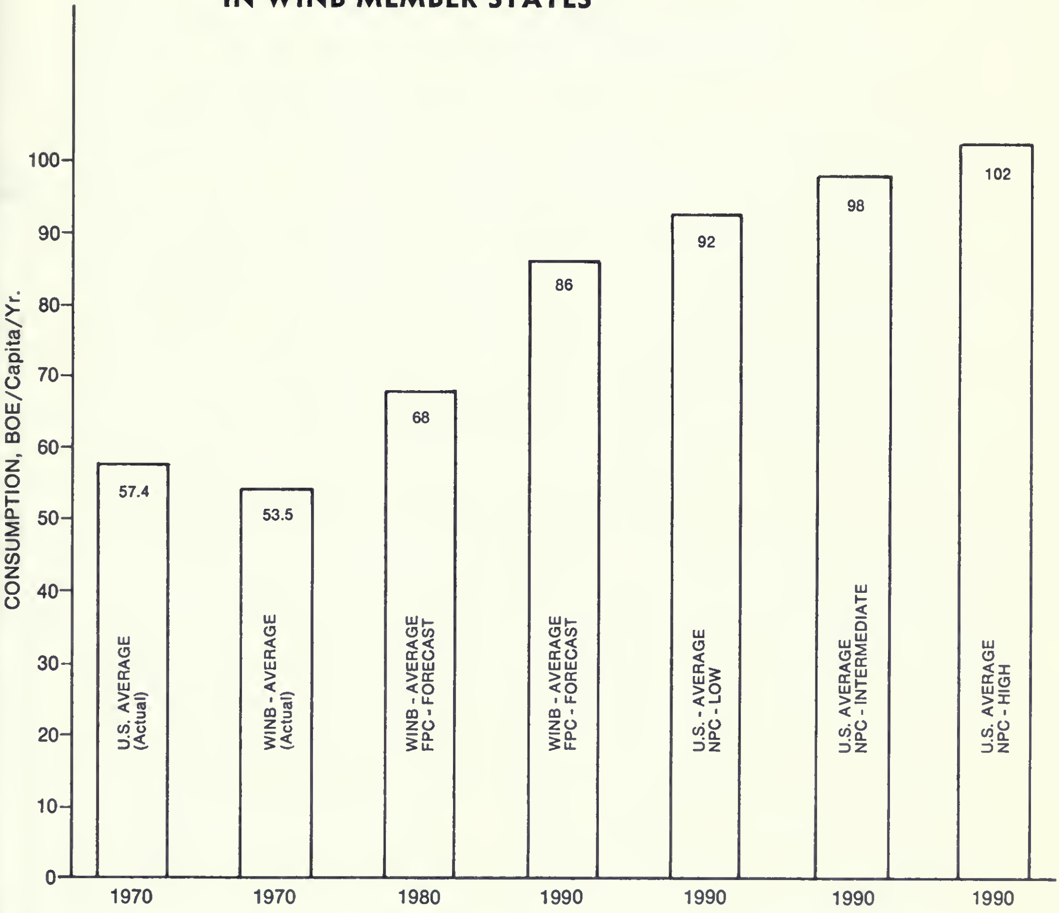
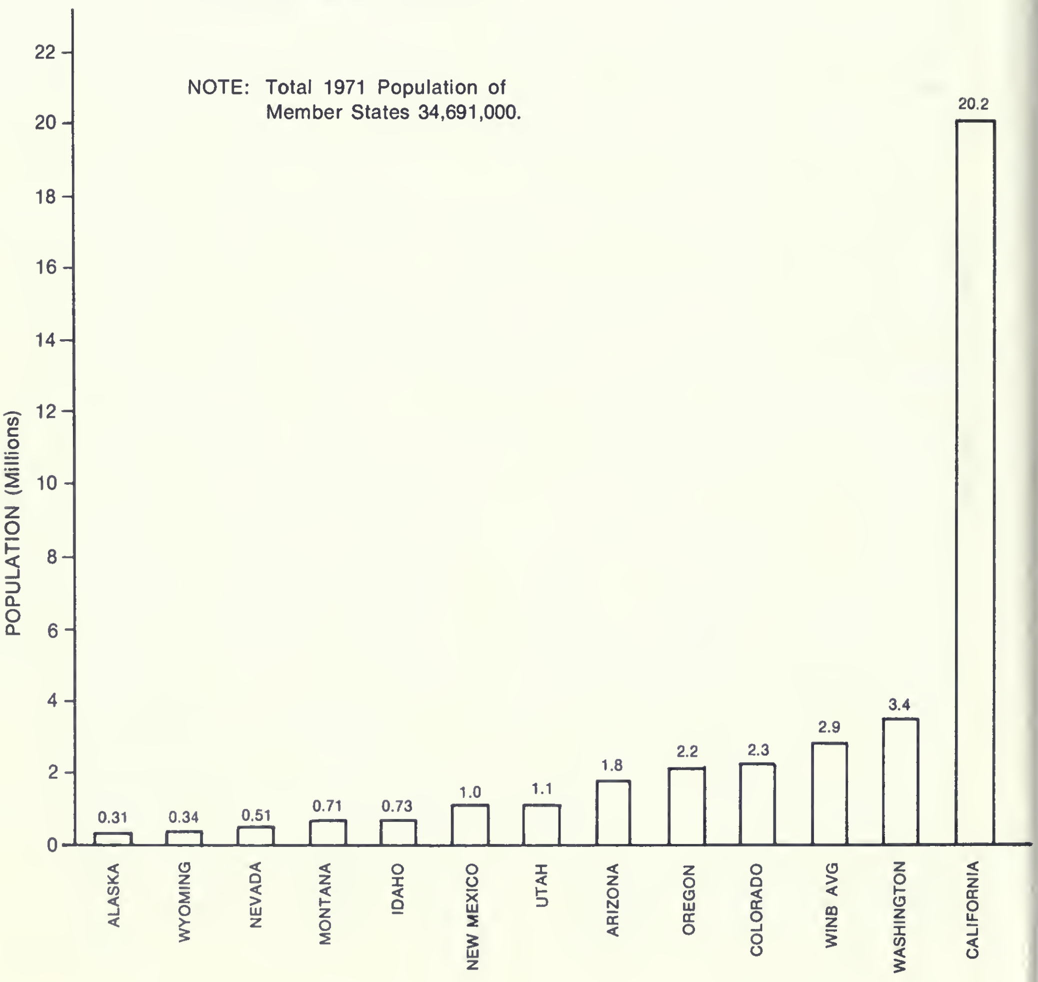


Figure 8

1971 POPULATION IN WESTERN STATES



NOTE: Total 1971 Population of Member States 34,691,000.

Table 2

SERIES I-E* POPULATION PROJECTION OF MEMBER STATES

(Thousands)

	April 1, 1970	1975	1980	1985	1990
Alaska	300	328	352	374	392
Arizona	1,771	1,974	2,164	2,352	2,523
California	19,953	22,077	24,226	26,429	28,485
Colorado	2,207	2,423	2,636	2,848	3,042
Idaho	713	735	761	790	817
Montana	694	706	721	739	757
Nevada	489	584	673	759	836
New Mexico	1,016	1,052	1,088	1,126	1,160
Oregon	2,091	2,257	2,421	2,591	2,749
Utah	1,059	1,146	1,234	1,322	1,400
Washington	3,409	3,682	3,958	4,236	4,489
Wyoming	332	336	342	351	360
Total West	34,034	37,300	40,576	43,917	47,010
Total U.S.A.	203,166	214,883	226,934	239,329	250,630
WINB Average	2,836	3,108	3,381	3,660	3,918

*Series P-25, No. 477, U.S. Census, March 1972

To overcome the population bias a unit has been instituted in this report that normalizes the energy consumption and production on a per capita basis. The unit is Barrels of Oil per capita per year (BOE/C/Yr.). It is most interesting to note that even though California uses the most energy, in total, it uses the least energy of the WINB member states on a per capita basis. As shown in Figure 9, southwestern states (except New Mexico) use less amounts of energy per capita than the WINB member states in the North. It is also interesting that the states (except Alaska) in which energy is especially abundant the per capita use is high. This is perhaps a measure of the elusive price and demand "elasticity". The operation of more coal-fired power plants in Wyoming and New Mexico may soon cause the "per capita" use of energy to rise even further in these two states. The operation of the trans-Alaska Pipeline will cause the production per capita in Alaska to rise drastically but the consumption per capita will remain moderate until Alaska has more refineries to meet its own energy needs.

Energy production in each of the WINB member states is shown in Figure 10. In 1971, New Mexico was a strong producer; second only to California. After the trans-Alaska pipeline reaches full capacity of 730 million BOE/yr. (2,000,000 BOE/day), Alaska will probably be the strongest producer of energy in the West. An equivalency unit is displayed in Figure 10, which shows that the current energy production in the average WINB member state is equivalent to about twelve 1,000 megawatt thermal power plants. The addition of 50 such plants in the West could make a very significant impact on the energy production in the West. The present three nuclear power plants in the West contribute only 0.6 percent of the total energy production in the West. By mid-1982, the scheduled fourteen new nuclear power units can add the equivalent of about 150 million barrels of oil per year.

The energy forms which compose the production and consumption in each of the western states is shown in Figure 11. The major net

ENERGY CONSUMPTION
IN WESTERN STATES – 1971

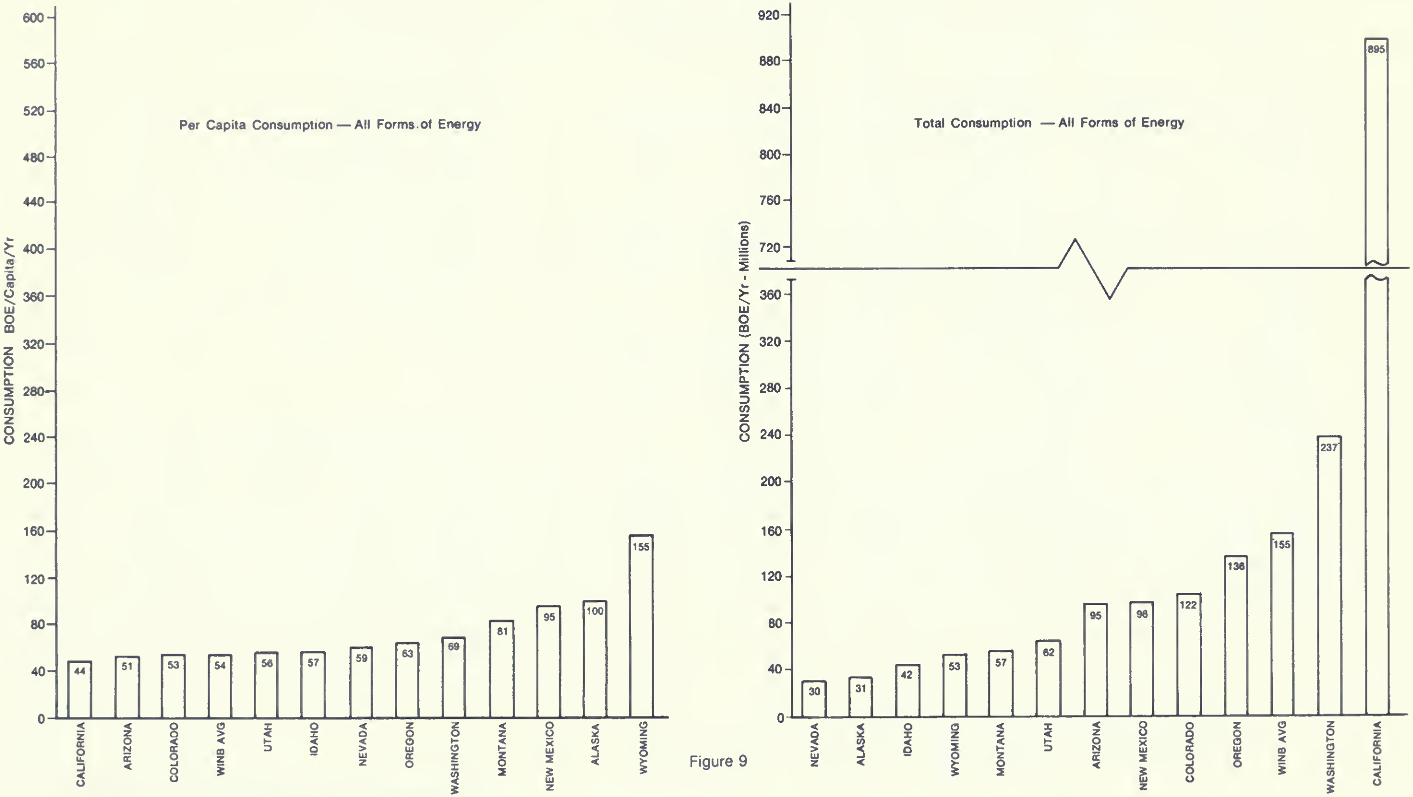
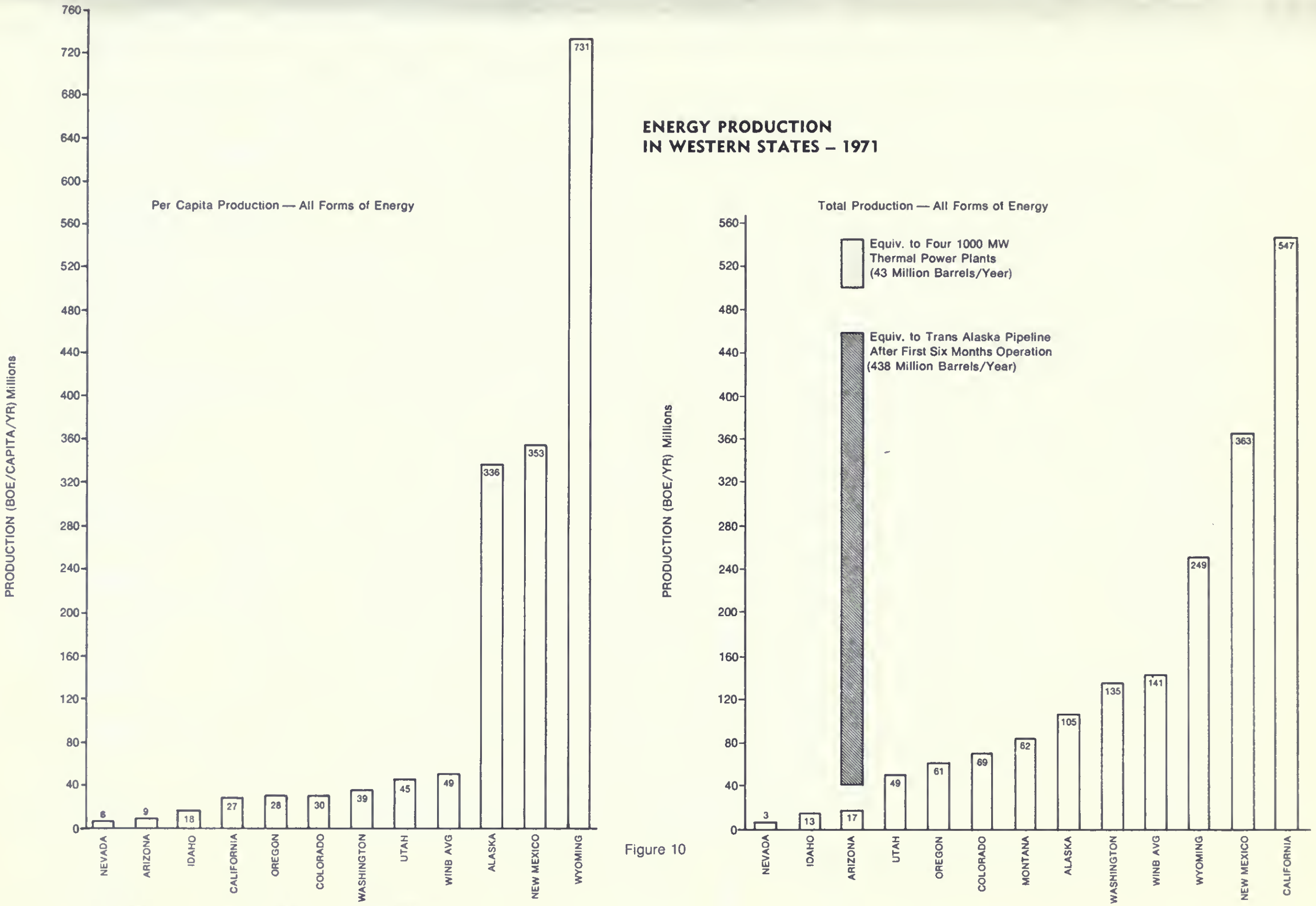


Figure 9

Source Data From U.S. Dept. of Interior Energy Fact Sheets—1971

ENERGY PRODUCTION IN WESTERN STATES – 1971



Source Data From U.S. Dept. of Interior Energy Fact Sheets—1971

Figure 10

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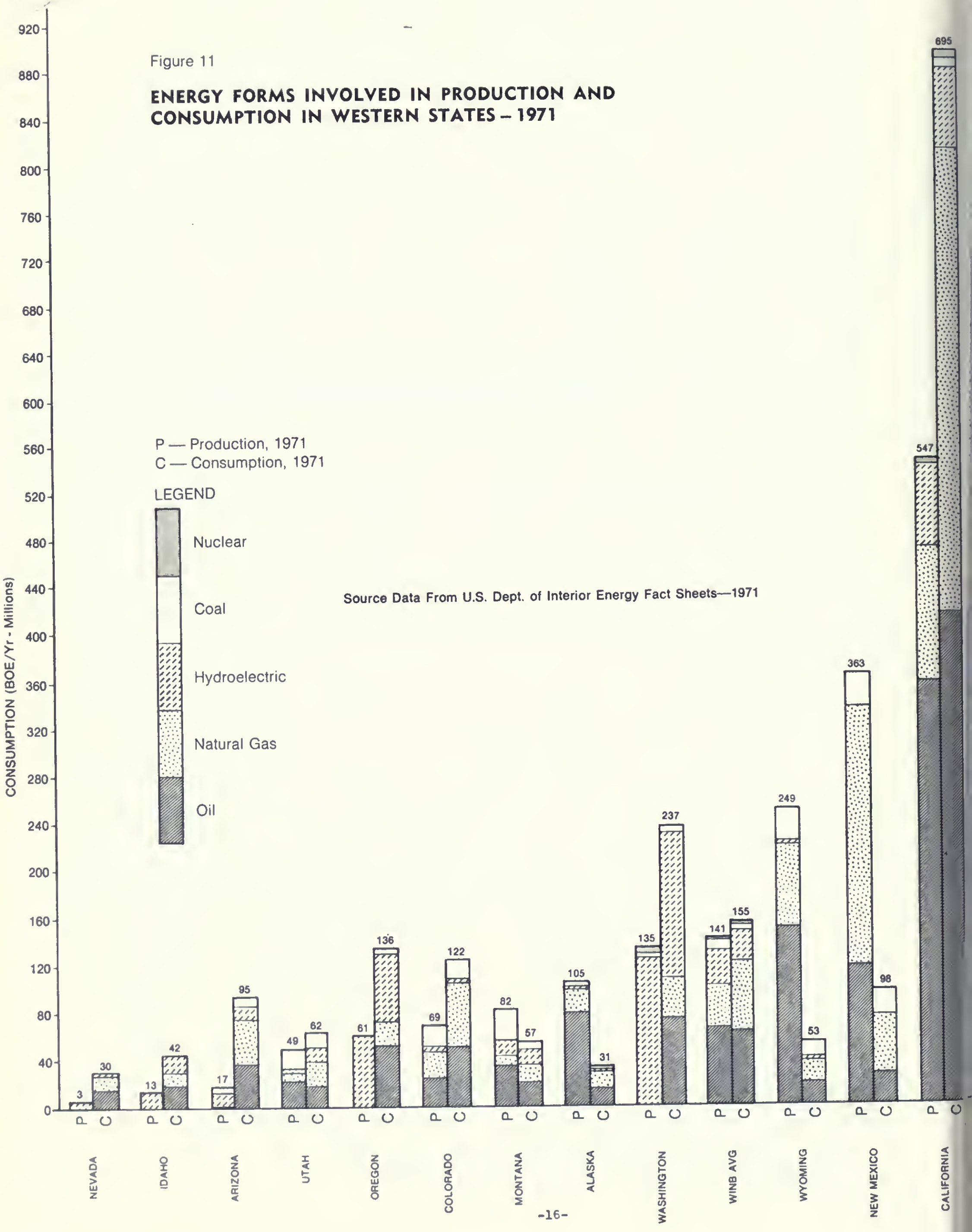


Figure 11

ENERGY FORMS INVOLVED IN PRODUCTION AND CONSUMPTION IN WESTERN STATES – 1971

Source Data From U.S. Dept. of Interior Energy Fact Sheets—1971 deficiency shown is in the consumption of natural gas in California.

The Federal Power Commission, in projecting the role which nuclear power will play in the western energy scene, made predictions in their 1964 and 1970 National Power Surveys. The FPC projections were made separately for electrical power from nuclear energy and electrical power from coal as shown in Figure 12. As a result of difficulties in siting and licensing nuclear plants since 1970 the use of coal as fuel for electrical generation has exceeded the FPC projection and the use of uranium as fuel has fallen short. The units shown as "planned" are actually scheduled by utilities within the Western States Coordinating Council (WSCC). The percentage of fuel represented by coal for electrical generation is expected to grow beyond the 28 percent shown in Figure 12. The percentage represented by uranium is expected to grow even faster. If these together represent 74 percent of the energy mix by 1990 the total thermal power generation by coal and uranium will be back on the FPC "target" again by 1990. To meet the slope shown in Figure 12, units will need to be added in the West at a rate of about four per year from 1982 to 1990. This rate does not appear to be excessive in view of the rate at which nuclear power units are expected to come "on-line" in 1980, 1981 and 1982.

From the above it can be seen that the consumption and production of energy in the Western states is a collection of contrasts. Some states have essentially no indigenous production capabilities and others have export capabilities. The net effect is displayed in Figure 13. The member states with a surplus of energy in 1971, include Alaska, Montana, New Mexico and Wyoming. The extent of the surplus was almost sufficient to compensate for the deficit in the other member states. The net difference within the WINB region is equivalent to sixteen 1,000 megawatt thermal power plants or about 23 percent of the 730 million barrels per year of oil that is scheduled to ultimately flow from the trans-Alaska pipeline. Outwardly it would appear that with the pipeline construction about ready to begin and 14 nuclear plants in some stage of planning or construction that the West can easily be self-sufficient by 1980. Such is not the case, however, when recognizing that the energy demands are expected to be 40 percent higher in 1980 than the consumption rate experienced in 1971. If petroleum products from present sources remained at the same level of availability in 1980 as in 1971 and all other energy sources also remained constant the deficit by 1980 would be 907 million BOE per year, equivalent to 25 thermal power plants of 1,000 megawatts capacity plus the equivalent of 87 percent of the ultimate capacity of the trans-Alaska pipeline.

Since it is not realistic to assume that the Western states will receive such a large fraction of the production through the trans-Alaska pipeline, and since the current petroleum supplies will probably decrease rather than to remain constant, it is probable that the 25,000 megawatts of thermal power plant capacity now planned the West will be inadequate for self-sufficiency by 1980. An obvious alternative is to reduce the rate of growth in the energy demands. For example, if the energy growth from 1971 to 1980 were to be 20 percent rather than 40 percent the demand on the trans-Alaska pipeline would then be only 32 percent providing 25,000 megawatts of new thermal capacity is available by then and all other energy supplies (including natural gas) remain constant. Therefore, the rate of growth can be considered a key factor in reducing energy deficiency in the West. The periods between now and 1980 will most likely remain deficient to a point at which energy availability will restrict and may even reduce industrial growth in the West. If scheduled nuclear and coal-fired projects are delayed, an even smaller fraction of the Alaskan oil will be available for the remainder of the nation for becoming independent of foreign energy sources.

4.0 ENERGY RESOURCES IN THE WEST

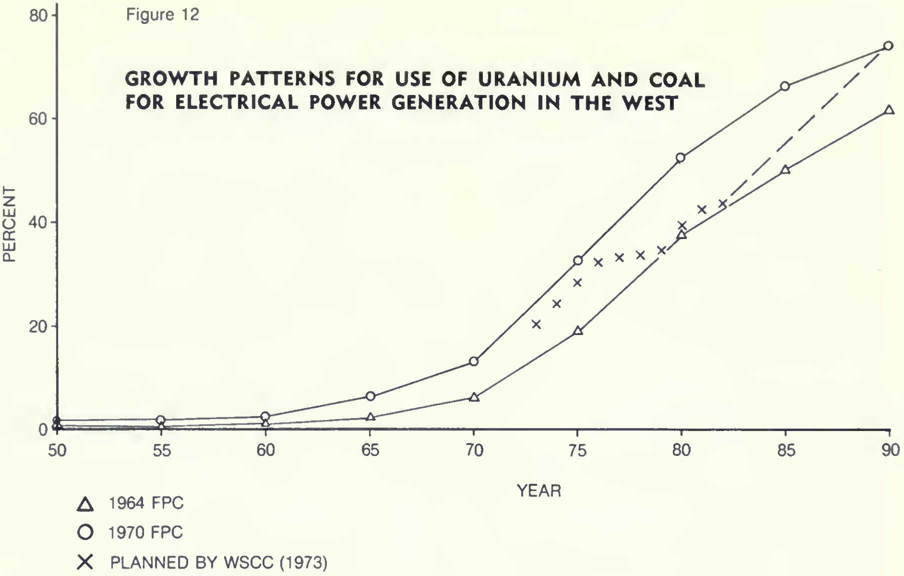
The West is extraordinarily well blessed with energy resources. The natural conditions and low cost funding have provided the hydropower needed to start productive industries here. The abundant oil and gas fields of California, and New Mexico, Utah and Wyoming have provided the energy resources to develop a strong economy in the West. The Rocky Mountain states, with their resources such as coal, uranium and oil shale provide the long-term possibility for the West to overcome its overall energy deficiency. Alaskan oil, gas and coal can assist the coastal load centers to meet energy needs until the coastal states can develop their own electrical generation resources with nuclear power. In addition, several western states have potentially significant quantities of geothermal power waiting to be tapped.

Perhaps of equal importance are the skilled technologists in the West who have blended these many and varied sources of power together to form an electrical distribution grid throughout the western states which is second to none.

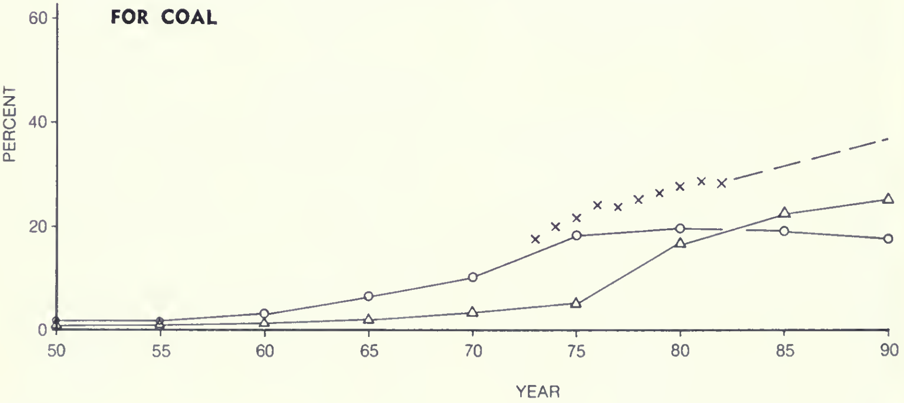
Advancing technology and the same energy resources are available to the West to permit this region to become a net exporter between 1980 and 1985. To do so it is essential that reliance be placed heavily on developed resources while continuing to investigate and develop other systems with potential of better economics, reliability and environmental impact.

Figure 12

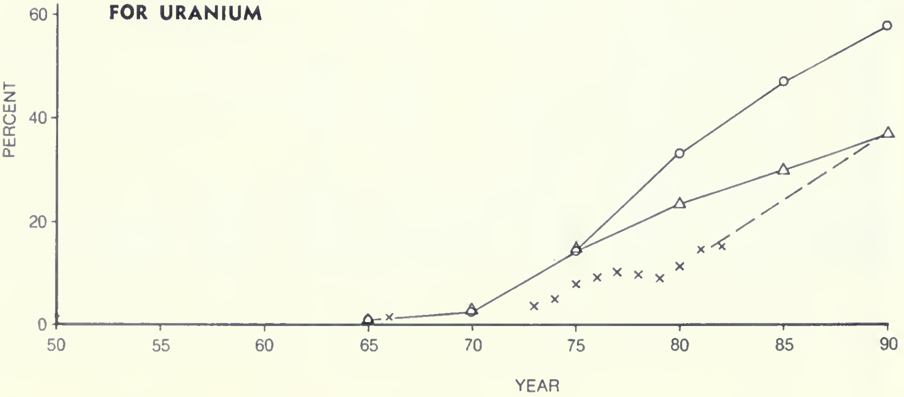
GROWTH PATTERNS FOR USE OF URANIUM AND COAL FOR ELECTRICAL POWER GENERATION IN THE WEST



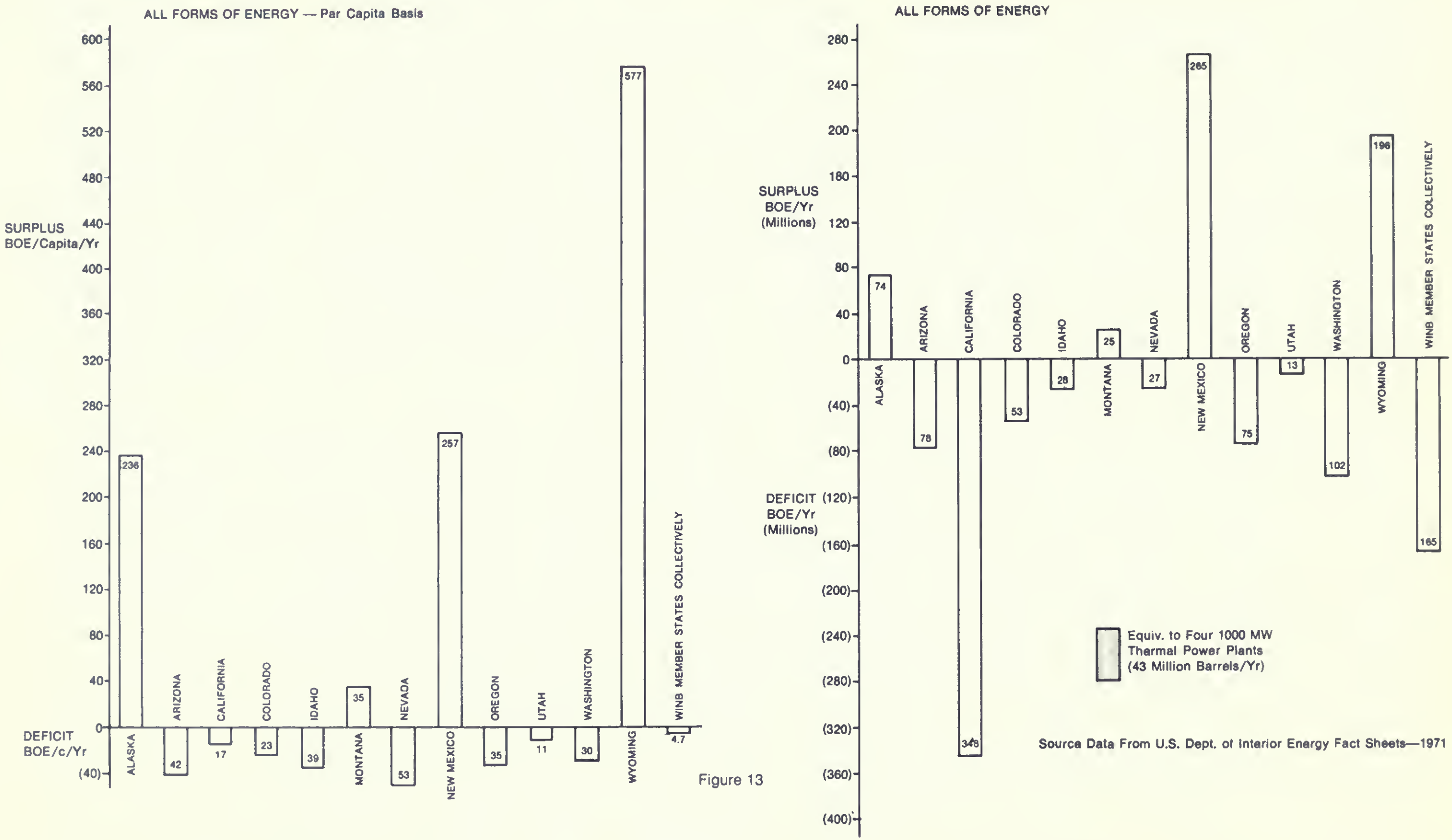
FOR COAL



FOR URANIUM



NET ENERGY BALANCES OF WESTERN STATES – 1971



Source Data From U.S. Dept. of Interior Energy Fact Sheets—1971

Figure 13

Table 3

Percentage Distribution by Energy Source for Electrical Generation in the West

	Thermal							
Year	Natural Gas	Oil	Coal	Nuclear	Other	Sub Total	Hydro	Total
Recorded:								
1950	13.6	6.7	1.2	0.0	1.0	22.5	77.5	100.0
1955	22.5	11.9	1.7	0.0	0.4	36.5	63.5	100.0
1960	29.6	10.8	2.9	0.1	0.3	43.6	56.4	100.0
1965	30.3	5.4	6.4	0.1	0.3	42.5	57.5	100.0
Projected:								
1970	30.1	5.5	9.9	2.6	0.3	48.4	51.6	100.0
1975	20.3	7.9	18.0	14.1	0.6	60.9	39.1	100.0
1980	12.2	5.5	19.6	32.9	0.7	70.9	29.1	100.0
1985	7.8	3.6	19.1	46.8	0.7	78.0	22.0	100.0
1990	6.3	2.5	17.2	56.9	0.6	83.5	16.5	100.0

Source: 1970 National Power Survey, Federal Power Commission, 1970

4.1 DEVELOPED RESOURCES

As shown in Section 3, the West was deficent in energy in 1971. It was also shown that energy in the West will be increasingly electrical in the future. Energy resource planning therefore is best placed on marshalling those resources that can be used for electrical production.

There are several energy resources for electrical production that can be considered "developed" at this time. The extent to which these developed resources have been used in the past two decades and the future role of these developed resources is presented in Table 3 and shown graphically in Figure 5. The AEC has recently recommended[8] expanded federal support for both developed and emerging energy sources.

4.11 HYDRO

Since the white man first settled in the West he has employed the weight and fluidity of water for performing useful work. The growth of hydroelectric power has been steady until recent years. Table 4 tabulates the past and projected progress on installing hydroelectric generation in the West. The large increase came in the 1960 - 1970 period. Beyond 1980 the only significant growth in hydroelectric power will be from pumped storage projects and the addition of turbines to existing dams to improve their peaking capacities.

Table 4

Hydroelectric Power Growth in the West

(Billion Kilowatt Hours)

1950	1960	1970	1980	1990
50.1	83.1	158.9	183.6	198.8

Source: 1970 National Power Survey, Federal Power Commission

Many of the developed hydroelectric sites in the Northwest have been on rivers in which migratory fish would customarily travel. Construction of dams in the past without adequate considerations of environmental effects has created illwill and pressure from sportsmen and other environmental groups. Such pressure and lack of many suitable sites will make it difficult to build any future major dams even in Idaho, Oregon and Washington.

4.12 NATURAL GAS

In the early 1930's the natural gas in the oil fields was considered a nuisance and burned at the wellhead. As pipelines and distribution systems developed natural gas began to be marketed. In 1938, the Federal Power Commission was ordered to regulate the price of natural gas involved in interstate commerce. The prices that the FPC held on natural gas in the intervening years have encouraged consumption and discouraged development of new gas reserves. With the increased drilling costs required to find new gasfields, the recent price increase permitted by the FPC still appears to be too low to warrant significant exploration and development. For those industries that must use natural gas some are installing small coal gasification plants and some are planning to use imported Liquified Natural Gas (LNG). Large specially designed tankers and deepwater ports are needed to import LNG at an economic price but few American ports are now prepared to handle such tankers. The Corps of Engineers has recently conducted a study[9] and held workshops on where deepwater ports would be most feasible on the West Coast. The results to date, tend to indicate that Los Angeles, San Francisco and Seattle, would be the favored locations by the Corps of Engineers.

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[8] "The Nation's Energy Future", Chairman, Dixie Lee Ray USAEC; Wash - 1281, Dec. 1, 1973.

Alaska is a likely source of LNG for the lower 48 states. The LNG can be vaporized at portside and used to fill existing pipelines but unless the FPC price for natural gas is significantly lifted in the U.S.A. it appears that much of the LNG traffic from Alaska will continue to go to Japan.

The flexibility and clean burning nature of natural gas make it a valuable energy resource for domestic heating and pollution control devices. There is consideration of restricting this valuable resource from its use as fuel for electrical power generation.

As an example, California has 20,000 megawatts of installed electrical generation capacity that is capable of burning natural gas or oil. If these plants burn gas 60 percent of the time, nearly one trillion cubic feet of natural gas would be consumed each year. This is equivalent to 180 million barrels of oil which is more than the West, collectively, is deficient in energy, as shown in Figure 13. This volume of gas is also equivalent to 17 nuclear units of 1000 megawatt capacity each.

Therefore, even though natural gas is available for electrical generation, the presence of nuclear power plants in California could relieve the burden on this precious resource which is piped from as far east as El Paso, Texas. Any further committment of natural gas for electrical generation should be on only a temporary or emergency basis.

Continued exploration and research to insure long term availability of natural gas to the West is essential.

4.13 PETROLEUM

Collectively, the western states were self-sufficient with respect to oil in 1971. The extent of production and consumption in each state is presented in Table 5. The same table shows a self-sufficiency of coal and a gross deficiency in natural gas. Even though California's oil production nearly met its consumption, in 1971, California's natural gas production missed its consumption by more than a factor of three. The trend in California oil and gas production was shown in Figure 4. It is readily apparent that California production cannot keep up with California consumption in the future without some significant changes (i.e. conservation measures, relief by more nuclear plants, offshore drilling, etc.)

With the coal, gas, and oil depletion rate in WINB member states shown in Table 6 it is clear that energy conservation must range beyond the Western coal and gas fields. Relief is needed on oil depletion in at least five western states. The oil and gas resources that are known in the West are shown in Figure 14. The importance to California of the trans-Alaska pipeline is readily apparent. With ready availability of the Alaskan low sulfur oil to California there is hope of being able to completely displace the use of natural gas in the electrical generating stations there. Therefore, an increased use of oil and a decreased use of gas has been forecast[10] for electrical generation in California.

Petroleum crude is also needed for a variety of other uses throughout the West. These include petrochemical production, fuel oil and gasoline production, etc. By 1990 it has been estimated that less than 9 percent of the electrical power generation will come from oil and natural gas.

Oil, just as any other natural resource, has a finite limit to its availability. The supply and demand curve will take a shape that is commensurate with its rate of recovery. Figure 15 is a demand curve that is extrapolated beyond a fairly well established base. Regardless of the actual amount recoverable, 80 percent of the resource appears destined to be consumed during a 60 year period. The peak in oil availability, worldwide, has been expected about the turn of the century but may have already been achieved. Further exploration is essential but so is a shift from such strong dependence on petroleum in the nation's economy. The higher costs for future exploration and recovery may soon reduce the demand.

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[9] Summary Report - West Coast Deepwater Port Facilities Study, United States Army Corps of Engineers, June 1973.

[10] Energy in California, Resources Agency, State of California, Jan. 1973.

Table 5

1971 Fossil Fuel Consumption and Production in the Western States

	Bituminous Coal and Lignite (1,000 tons)			Crude Oil (1,000 bbls)			Natural Gas (1,000,000 cu.ft.)		
	Produced	Consumed	Net	Produced	Consumed[1]	Net	Produced	Consumed	Net
Alaska	698	748	(50)	79,494	15,503	63,991	121,618	67,706	53,912
Arizona	1,146	2,324	(1,178)	1,236	36,097	(34,861)	868	213,313	(212,445)
California	0	1,847	(1,847)	358,484	415,298	(56,814)	612,629	2,149,264	(1,536,635)
Colorado	5,337	4,475	862	27,391	49,906	(22,515)	108,537	289,369	(180,832)
Idaho	0	2/	--	0	19,134	(19,134)	0	50,096	(50,096)
Montana	7,064	1,348[3]	5,716	34,599	19,316	15,283	32,720	88,271	(55,551)
Nevada	0	0[4]	0	113	14,766	(14,653)	0	66,511	(66,511)
New Mexico	8,175	6,713	1,462	118,412	25,114	93,298	1,167,577	269,368	898,209
Oregon	0	1,482	(1,482)	0	51,379	(51,379)	0	100,897	(100,897)
Utah	4,626	2,993	1,633	23,630	27,121	(3,491)	42,418	121,403	(78,985)
Washington	1,134	0	1,134	0	76,884	(76,884)	0	156,663	(156,663)
Wyoming	8,052	3,728	4,324	148,114	16,099	132,015	380,105	115,286	264,819
Total	36,232	25,658	10,574	791,473	766,527	24,946	2,466,472	3,688,147	(1,221,675)

1/ Consumption is based on volume of petroleum products rather than volume of crude
2/ See Montana
3/ Includes Idaho
4/ A total of 712,000 tons was consumed at Reid Gardner and Mohave plant according to the Nevada Power Company report.

Source: U.S. Department of Interior, Energy Fact Sheets - 1971.

1971 RATE OF TAPPING ESTIMATED RECOVERABLE RESERVES OF FOSSIL FUELS IN WESTERN STATES

	Bituminous Coal & Lignite (1,000,000 tons)			Crude Oil (1,000,000 Bbls)			Natural Gas (Trillion Cu. Ft.)		
	1971	Reserves	%	1971	Reserves	%	1971	Reserves	%
Alaska	.698	59,523	0.0012	79.494	10,116	0.79	121 618	31,365	.38
Arizona	1.146	12,465	0.0092	1 236	N.A.	N.A.	.868	N.A.	--
California	0	29	0	358.484	3,706	9.7	612.629	5,730	11.
Colorado	5.337	37,873	0.014	27.391	333	8.2	108.537	1,818	6.0
Idaho	0	5	0	0	0	--	0	0	--
Montana	7.064	61,050	0.012	34.599	228	15.2	32.720	1,025	3.2
Nevada	0	0	--	.113	N.A.	--	0	0	--
New Mexico	8.175	27,792	0.029	118.412	657	18.0	1.167.577	13,068	8.9
Oregon	0	37	0	0	0	0	0	N.A.	--
Utah	4.626	13,600	0.034	23.630	166	14.3	42.418	982	
Washington	1.134	2,551	0.043	0	0	--	0	N.A.	--
Wyoming	8.052	75,582	0.011	148.114	997	14.9	380.105	4,132	9.2
Total Western States		290,507			16,221			58,119	
Total U.S.A.		578,391			38,063			278,805	

Note: Fossil fuel resources in Alaska as estimated by the Alaska Power Authority exceed the above quantities by the following percentages: Coal by 200%; Crude oil by 50%; Natural Gas by 10%. Other estimates of oil and gas reserves have exceeded the above Bureau of Mines date on gas and oil by factors of 3 and 4 respectively. Even with the above Bureau of Mines estimate Alaskan oil reserves are almost 3X that of the next larger WINB member state.

Source: U.S. Bureau of Mines, Minerals Yearbook - 1971

Reducing the scale of the same curve and comparing it with the demand cycle for coal (Figure 16) it can be seen what some observers have referred to as an "oil binge". Given in this broader perspective, it is easier to see why the Federal Power Commission has suggested that less than 9 percent of our electrical generation in 1990 should come from a combination of oil and gas.

In a day when oil sold for $4.00 per barrel and was one of the cheapest energy commodities available it was difficult to feature a long-lived supply. Action by the Arab states to decrease production and to increase prices will assist in the longevity of this resource but not without a difficult period of adjustment by the industrial nations that have grown dependent upon oil from the Middle East.

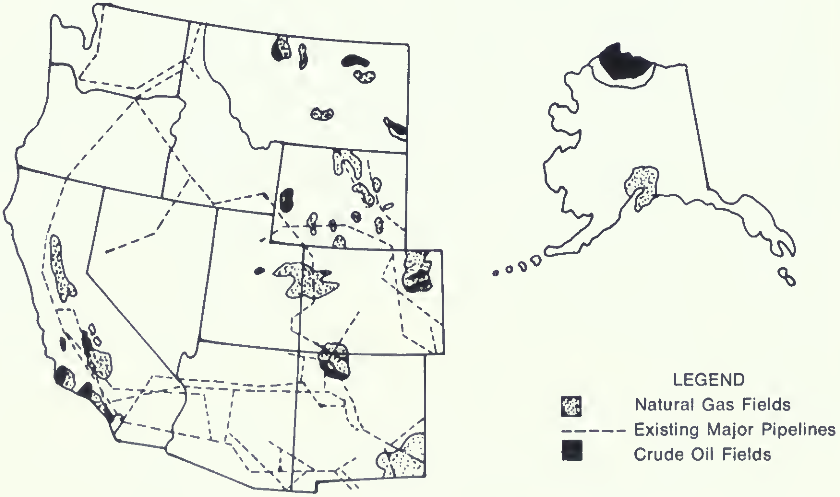
In view of the rate of use and finite limits on oil and gas resources it appears even more incumbent upon current world leaders to develop alternate fuels for generating electrical power and to conserve petroleum for applications in which it is uniquely qualified such as for transportation, and certain chemicals, etc.

4.14 COAL

It has become increasingly evident in recent months that a resurgence in the use of coal will be necessary to meet our domestic power needs. The coal fields of the Western United States are of the low-sulfur quality urged by the Environmental Protection Agency. Unit trains of this coal are and will continue to be shipped to points east, from the eastern slope of Montana. On the western slope of Wyoming and in Montana coal is being used to generate electrical power for points west. New Mexico and Arizona also have large quantities of coal that will be useful in maintaining the economy of the Southwest until nuclear power plants can be constructed.

The coal deposits of the West are shown in Figure 17. The high grade bituminous coal in Utah and Colorado are accessible by underground mining and are therefore expensive compared with strip mining. Using high volume equipment the surface mining and burning of even lignite is economic in the Rockies. Most coal in Montana is of the sub-bituminous and lignite varieties but by surface mining it is economical to ship this coal to even Chicago and points beyond.

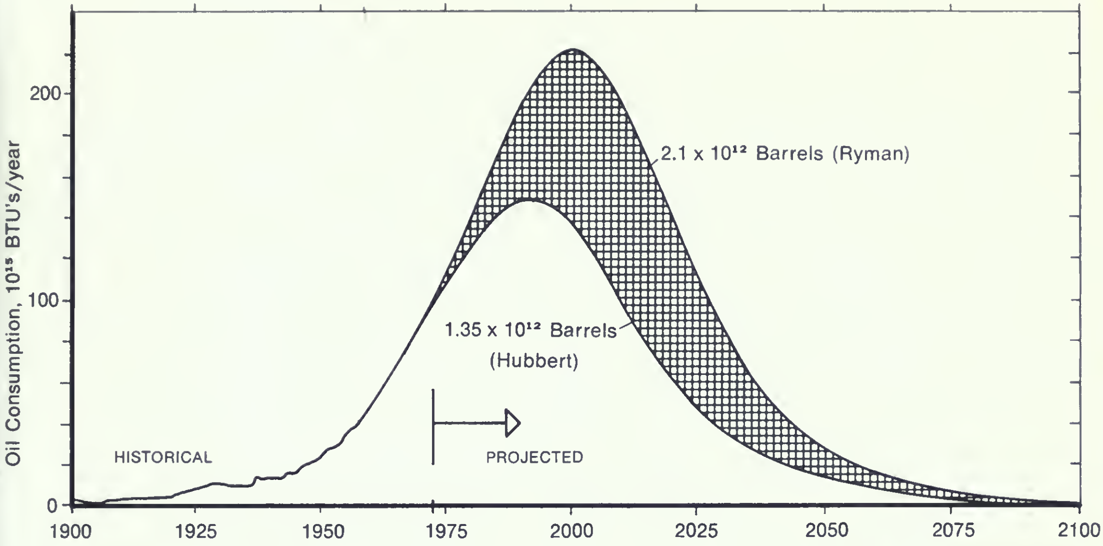
The historical coal production in the western states is shown in Table 7. The recent increases in Wyoming are significant as new power plants are being located there. The production in Montana has essentially doubled in each of the last four years reported. Even with the production shown, the West produces



MAJOR CRUDE OIL AND NATURAL GAS FIELDS IN WINB STATES

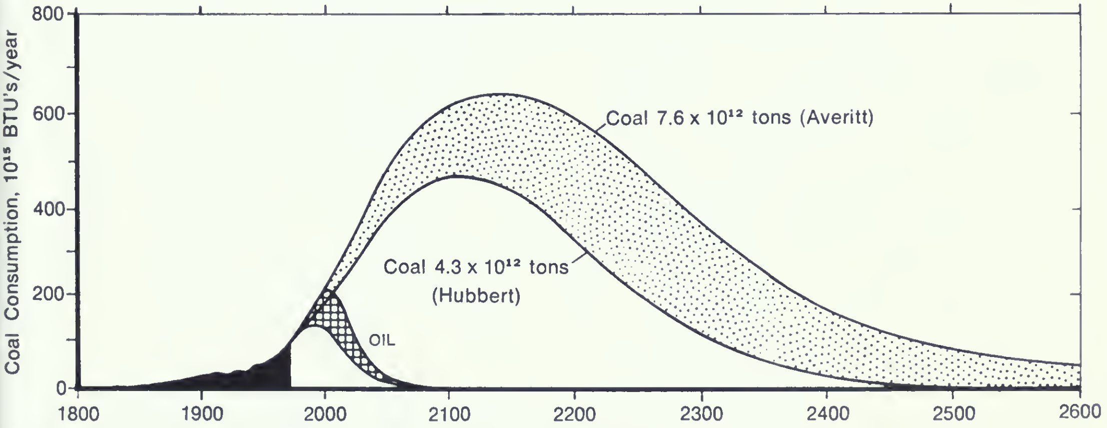
Note. Alaska not shown to scale. Oil shale deposits not shown.

Figure 14



World demand cycle on global oil resources (adapted from M. K. Hubbert, 1971)

Figure 15



Projected demand cycle on global fossil fuel reserves (adapted from M. K. Hubbert, 1971)

Figure 16

COAL FIELDS IN WINB MEMBER STATES

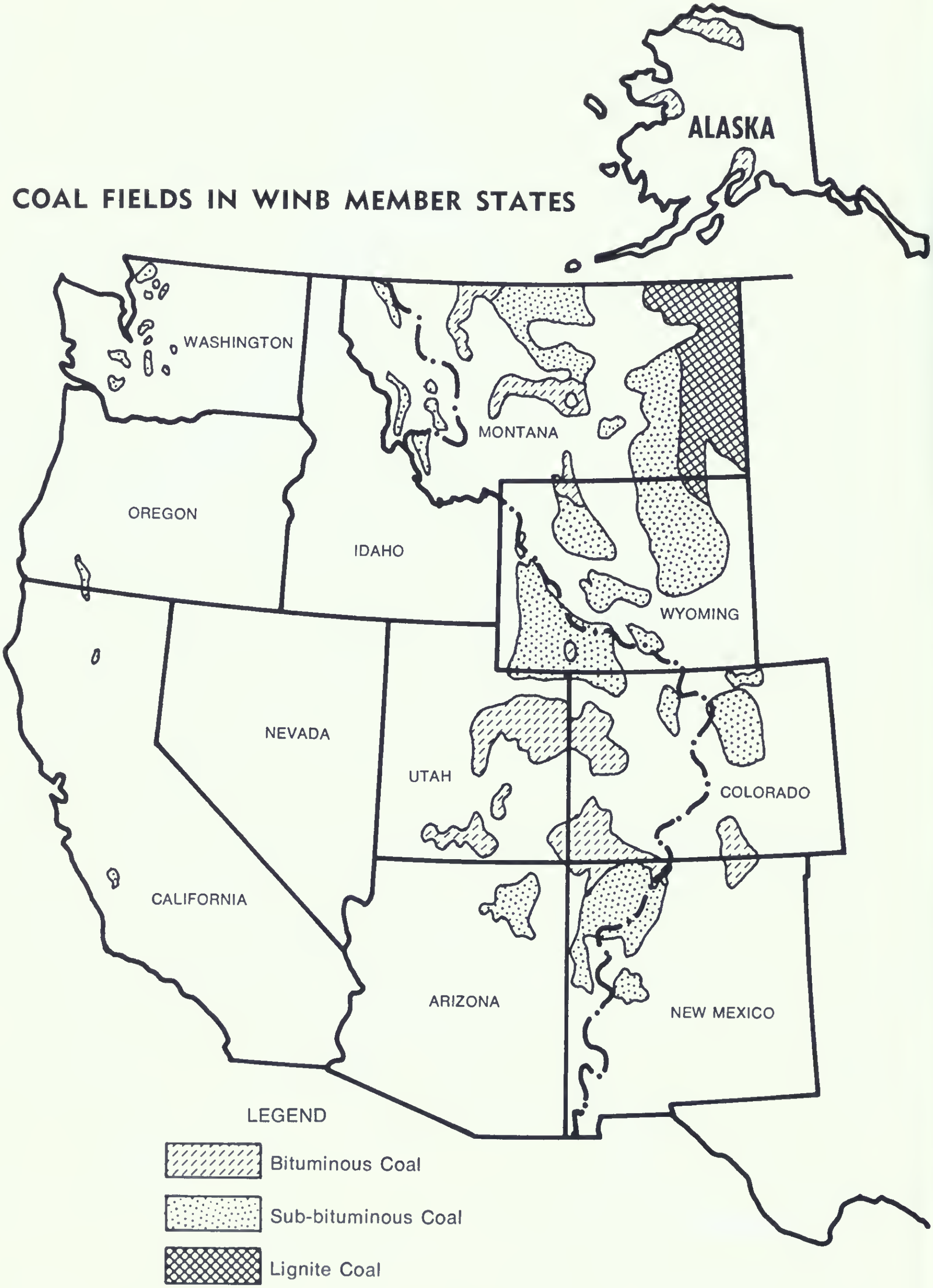


Figure 17

Table 7

HISTORICAL COAL PRODUCTION IN WESTERN STATES (1,000 Tons)

	Alaska	Arizona	Colorado	New Mexico	Utah	Washington	Wyoming	Montana	
1946			5914	1280	5994	991	7636	3520	a
1950			4259	727	6670	874	6348	2512	a
1955			5368	210	6296	610	2927	1212	a
1960	--	--	3607	295	4955	228	2024	313	a
1965	--	--	4790	3212	4992	55	3260	364	a
1967	—	1	5439	3463	4175	59	3588	371	b
1968	750	--	5558	3429	4316	178	3829	519	b
1969	667	--	5530	4471	4657	58	4602	1030	b
1970	549	132	6025	7361	4733	37	7222	3447	b
1971	698	1146	5337	8175	4626	1134	8052	6737	c

Reference

a 1966 Minerals Yearbook, Vol 1

b 1970 Minerals Yearbook, Vol 2

c 1971 Minerals Yearbook, Vol 1

Note - Total 1971 production for WINB member states was 36.6 million tons.

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only seven percent of the total national production. For having such a valuable energy resource under the western states it is expected that the production in the Rocky Mountain states will continue to rise dramatically, above the 0.01 percent depletion rate shown in Table 6.

Coal from the Black Mesa in Arizona is piped in an 18-inch slurry pipeline to the Mohave plants in Nevada. Except for this, most of the coal-fired plants in the West are near the mines. The twenty-three coal-fired power plants that currently exist in the West are shown in Table 8 and have a total power rating just over 9,000 megawatts. As shown in Table 9, new coal-fired generation that is planned to be operational by 1982, totals nearly 19,000 megawatts. By 1980, the total coal-fired electrical generation expected in the West will exceed the 1970 FPC estimate by 50 percent. This rapid growth rate is partly accounted for by delays in nuclear schedules.

Commerce from the mining of coal was not large unto itself, in 1971, as shown in table 10. In fueling the coal-fired electrical generating plants already scheduled for the West, coal production will need to increase by a factor of three. By 1982, the coal-fired generation will require about 100 million tons/yr. Export

Table 8

EXISTING COAL-FIRED ELECTRICAL GENERATION PLANTS IN THE WEST

Centralia, Washington	1400. MW
Salt Lake City, Utah	241.
Drem, Utah	63.
Castle Gate, Utah	166.
Kemmerer, Wyoming	707.
Billings, Montana	180.
Joseph City, Arizona	120.
Cedar City, Utah	7.
Farmington, New Mexico	2172.
Denver, Colorado	724.
Boulder, Colorado	297.
Denver, Colorado	240.
Grand Junction	75.
Alamosa, Colorado	21.
Glenrock, Wyoming	758.
Green River, Wyoming	15.
Somerset, Wyoming	3.
Acme, Wyoming	12.
Nucla, Colorado	39.
Hayden, Colorado	158.
Ft. Collins	8.
Mohave, Nevada	1460.
Moapa, Nevada	234.
	9110. MW

Table 9

COAL-FIRED POWER PLANTS SCHEDULED FOR WINB MEMBER STATES

Operational	Site	Name	Rating, MW (Net electric)	Location
Dec. 1972		All existing to Dec. 31, 1972	9,110	West
Jan. 1973	1	Mohave No. 2	60 (Rerate)	Nevada
Sept. 1973	2	San Juan No. 2	330	New Mexico
Jan. 1974	1	Mohave No. 1	30 (Rerate)	Nevada
Jan. 1974	1	Mohave No. 2	30 (Rerate)	Nevada
Jan. 1974	3	Comanche No. 1	350	Colorado
May 1974	4	Navajo No. 1	750	New Mexico
Jun. 1974	5	Jim Bridger No. 1	550	Wyoming
Jun. 1974	6	Huntington Canyon No. 1'	430	Utah
May 1975	4	Navajo No. 2	750	New Mexico
Jun. 1975	7	R. Gardner No. 3	117	Nevada
Jul. 1975	8	Colstrip No. 1	330	Montana
Sept. 1975	5	Jim Bridger No. 2	500	Wyoming
Jan. 1976	3	Comanche No. 2	350	Colorado
Apr. 1976	9	Hayden No. 2	250	Colorado
May 1976	4	Navajo No. 3	750	New Mexico
Jun. 1976	10	Cholla No. 2	250	New Mexico
Jul. 1976	8	Colstrip No. 2	330	Montana
Sept. 1976	5	Jim Bridger No. 3	500	Wyoming
Dec. 1976	2	San Juan No. 1	340	New Mexico
Jun. 1977	10	Cholla No. 3	250	New Mexico
May 1977	11	Wyodak	330	Wyoming
Jun. 1977	6	Huntington Canyon No. 2	430	Utah
Oct. 1977	12	City of Colorado Springs	180	Colorado
Apr. 1978	*	Public Service of Colorado	500	Colorado
Apr. 1978	9	Craig No. 1	350	Colorado
May 1978	*	Salt River Project	250	New Mexico
Jun. 1978	2	San Juan No. 3	500	New Mexico
Jun. 1978	13	Arrow Canyon No. 1	500	Nevada
Apr. 1979	*	Public Service of Colorado	500	Colorado
Apr. 1979	9	Craig No. 2	350	Colorado
Jun. 1979	13	Arrow Canyon No. 2	500	Nevada
Jun. 1979	14	Emery No. 1	530	Utah
Jul. 1979	8	Colstrip No. 4	700	Montana
Apr. 1980	*	Idaho Power Co.	500	Idaho
Jun. 1980	15	Kaiparowits No. 1	1,000	Utah
Jun. 1980	13	Arrow Canyon No. 3	500	Nevada
Jun. 1980	2	San Juan No. 4	500	New Mexico
Jul. 1980	8	Colstrip No. 3	700	Montana
Oct. 1980	12	City of Colorado Springs	200	Colorado
Apr. 1981	*	Idaho Power Co.	500	Idaho
Apr. 1981	*	Public Service of Colorado	500	Colorado
Jun. 1981	13	Arrow Canyon No. 4	500	Nevada
Jun. 1981	15	Kaiparowits No. 2	1,000	Utah
Jun. 1982	15	Kaiparowits No. 3	1,000	Utah
		Total since Dec. 1972	18,767	
		Total	27,877	

*unassigned

Table 10

Commerce From Production of Coal in Western States - 1971

State	No. of Mines	Type	Total Production (1,000 tons)	Value/ton (average)	Commerce ($, millions)
Alaska	4	Strip	698	$8.18	$ 5.7
Arizona	1	Strip	1147	withheld	2.0 (est.)
Colorado	32	Underground	3329		
	9	Strip	2008		
			5337	6.34	33.8
Montana	4	Underground	20		
	6	Strip	6717		
			6737	1.79	12.0
New Mexico	1	Underground	977		
	2	Strip	7198		
			8175	1.82	14.9
Utah	21	Underground	4620		
	1	Strip	6		
			4626	7.37	34.1
Washington	2	Underground	32		
	2	Strip	1102		
			1134	6.72	7.6
Wyoming	4	Underground	141		
	9	Strip	7899		
	1	Auger	12		
	99		8052	3.39	27.2
					137.3

Ref: 1971 Minerals Yearbook - 1971, U.S. Bureau of Mines

of coal from the region will also be more significant by 1982. Nationally, it is expected[8] that 600 million tons of coal will be consumed annually, by 1985. When coal is used to produce pipeline gas the consumption rate and added value will be expanded substantially.

With the unprecedented extraction rate on the nation's coal resources the efficiency with which it can be recovered and handled should attract funding support. Likewise restoration of strip mined areas should be well funded.

4.15 NUCLEAR

As shown in Table 11, the West still has only three nuclear power plants that are operational and generating electrical power. Six are under construction and eight more are scheduled to be operational by 1982. The six under construction were pruchased by the utilities in the late 1960's and will be coming "on-line" in the late 1970's. These plants will be the forerunners of units than can be used to make the West a net exporter with respect to energy by 1985.

Following 1977, the current schedule does not indicate another nuclear plant completion in the West until 1980. Starting in 1980, however, nuclear power units in the West are expected to come "on-line" at a rate of about three or four per year to 1990. The United States nuclear industry will complete about 125,000 megawatts of new generating capacity by 1980. The growth rate to and beyond that point will depend on streamlining the licensing process. The current licensing rate may permit the completion of 460,000 megawatts by 1990. The nuclear industry has recently concluded[11] that it is capable of

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[8] USAEC, Wash - 1281, Op. Cit.

[11] Resource Needs for Nuclear Power Growth, Atomic Industrial Forum, New York, 1973.

Table 11

EXISTING AND SCHEDULED NUCLEAR POWER PLANTS IN THE WINB MEMBER STATES

EXISTING

		NAME	RATING (Net. Electric)	STATE	SITE
	1963	Humboldt	68	California	A
	1966	Hanford No. 1	800	Washington	B
	1967	San Onofre No. 1	430	California	C
		Sub-total	1298		

PLANNED

Dec.	1973	Ft. St. Vrain	330	Colorado	D
Jul.	1974	Rancho Seco No. 1	913	California	E
Sept.	1975	Diablo Canyon No. 1	1084	California	F
Jul.	1975	Trojan	1130	Oregon	G
June	1976	Diablo Canyon No. 2	1106	California	F
Sept.	1977	Hanford No. 2	1100	Washington	B
Sept.	1980	San Onofre No. 2	1140	California	C
Sept.	1980	Hanford No. 1	406 (Rerate)	Washington	B
Sept.	1980	Boardman No. 1	1150	Oregon	H
June	1981	Arizona	1260	Arizona	I
Sept.	1981	WPPSS No. 3	1240	Washington	L
Dec.	1981	San Onofre No. 3	1140	California	C
June	1982	HTGR No. 1	770	California	J
July	1982	Skagit	1200	Washington	K
		Sub-total	13,969 MW		
		Total	15,267 MW		

producing nuclear plants at a rate that would permit completion of 7000,000 megawatts (e) by 1990 under high priority conditions.

Despite the 1977-79 lag in nuclear plant completion the electrical demands will continue to grow. The utilities have sensed the need for coverage in this period and have already contracted for power from the coal-rich part of the West. Table 9 is a good indication of how the utilities in the West have signed for coal power during this lag period. Even one year ago many of the plants had not been decided. For the long term it appears, however, that the utilities on the West Coast would prefer to use uranium as an energy source.

Locations of the existing and scheduled nuclear power plant sites are listed in Table 11 and shown in Figure 18. Note that the plants are mostly within the proximity of the heavy load centers of the West. Despite the obvious economic incentives of locating the plants near the load centers, some of the sites have attracted the interest of public action groups.

The public interest and involvement in nuclear plant siting is not limited to the West. Schedules have lagged throughout the nation for one to two years on most of the nuclear power plants that are currently under construction. Some of the delay has been from public groups and some simply from the difficulty of keeping $400 million projects on schedule. There has been little contingency planning on the part of the utilities thus the delays have been especially painful to power resource planners.

It is becoming increasingly clear that, to rely upon nuclear power plants at a particular time in the future, an inventory of acceptable sites needs to be established and a completion date targeted in advance of their need.

As nuclear power becomes a more significant energy source in the nation the uranium deposits will become more of a contribution in making the West a net export region. Figure 19 shows where 87 percent of the domestic uranium mining is performed in WINB member states. The energy contribution in 1971, from uranium was small nationally and was omitted in deriving the energy balances shown in Section 3.

If 87 percent of the installed nuclear capacity in the U.S.A. is powered by western uranium then the 125,000 megawatts expected to be installed in 1980 will be equivalent to about 450 million BOE per year; and the 460,000 megawatts expected by 1990 will be equivalent to about 1600 million BOE per year. This is a very significant contribution towards making the western states a net exporter of energy. As previously noted, the trans-Alaska pipeline at full capacity will be able to deliver 730 million BOE per year. This energy flow is expected to be exceeded by uranium from the member states before 1985 when the equivalent of 900 million BOE per year will be used in 250,000 megawatts of installed nuclear generating plants throughout the U.S.A. The nuclear plants planned for the U.S.A. are shown in Figure 20. Although the 21,687 megawatts of installed capacity in the U.S.A., on September 30, 1973 is new, it is equivalent to over 90 million BOE per year.

Breeder reactors and converter reactors (Using the thorium cycle) must continue to attract federal support and development. Although the high temperature gas converter reactors have already reached a respectable scale they do not yet represent much relief to what may be a high depletion rate of our domestic uranium reserves. Neither gas cooled nor liquid metal cooled breeder reactors are likely to produce a significant contribution to the nation's energy needs before the mid-1990's.

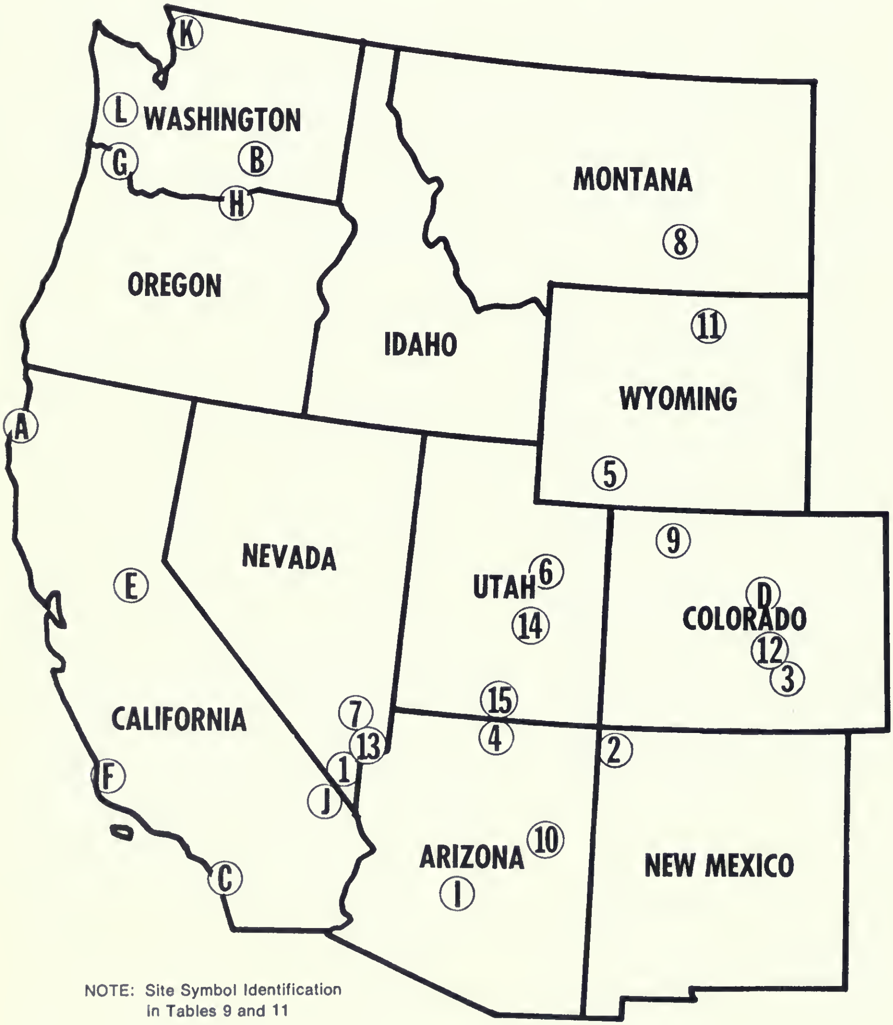
Importation of uranium in exchange for enrichment services may be a way of extending the uranium reserves of the West.

4.2 POTENTIAL NEW RESOURCES

The ever increasing demand for electrical power has prompted scientists to consider a variety of energy sources in past decades. However, with ample coal, natural gas and oil, in the '60's the utilities became interested in only nuclear power as a new energy resource. Now, with increasing costs, tightening schedules, and being tested for environmental impact, the utilities have become more receptive to considering a variety of potential new energy sources.

Utilities have sponsored studies on geothermal power and some have operating units. The utilities are viewing recent developments in breeder reactor and fusion research with intrest and substantial financial support. Systems that have little chance of meeting the growing generation resource deficits of the

LOCATION OF SCHEDULED NEW COAL AND NUCLEAR POWERED ELECTRICAL GENERATION FACILITIES



NOTE: Site Symbol Identification in Tables 9 and 11

Figure 18

utilities have generally failed to spark their interest. This includes wind-power and tidal-power.

The following energy sources are virtually undeveloped and could support parts of the energy needs of the nation thus they warrant further study by the government and the utilities.

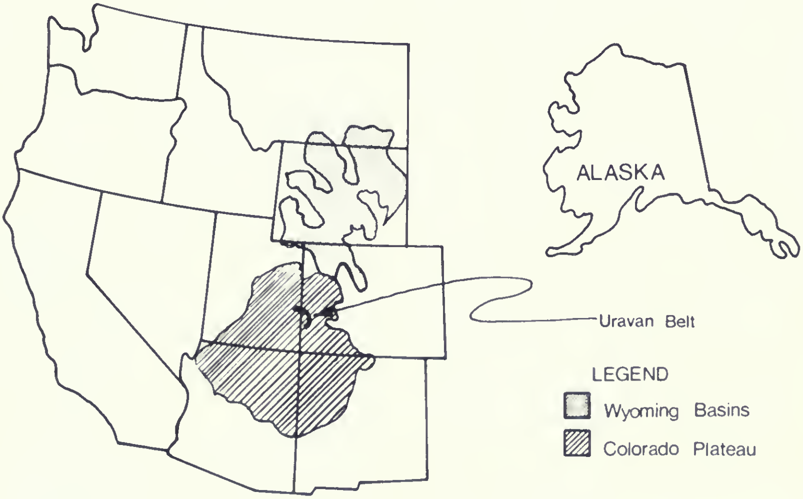
4.21 GEOTHERMAL

Taking heat from the inside of the earth has appeared to many observers to be the lowest cost fuel system imaginable. To others it has appeared to be a form of power generation with the least environmental impact. Whereas, it may be shown to have strong credits in both fields it remains to be seen just how economic and non-polluting it really can be. Proof may come with the establishment of two classes of wells in more than one location.

The two classes of wells are hot-dry and hot-wet. The hot-dry holes would require the introduction of water to create steam and the hot-wet holes have water already available to create steam. The premise is that hot-dry rocks may have a greater potential than the surface manifestations that we observe as geysers, for example. From either type of well, temperatures of 250°C are sought. Below 180°C, system efficiency is improved by transferring the heat from the hot water, or steam, to low boiling point organic liquids. Closed cycle conversion systems are in the process of development for use when geothermal fields are established.

Geothermal power is expected to be found in a broad swath across the West, which is especially shallow in the Great Basin region. Figure 21 is a generalized depiction based on surface observations throughout the West. California and Alaska also have significant geothermal potential. In California, the principal activity is found in the Geysers area and in the Imperial Valley. In Alaska, the principal activity is in the Aleutian Islands and in the Seward Penninsula, north of Nome.

PRINCIPAL URANIUM PRODUCING AREAS FOR 87% OF U.S. PRODUCTION

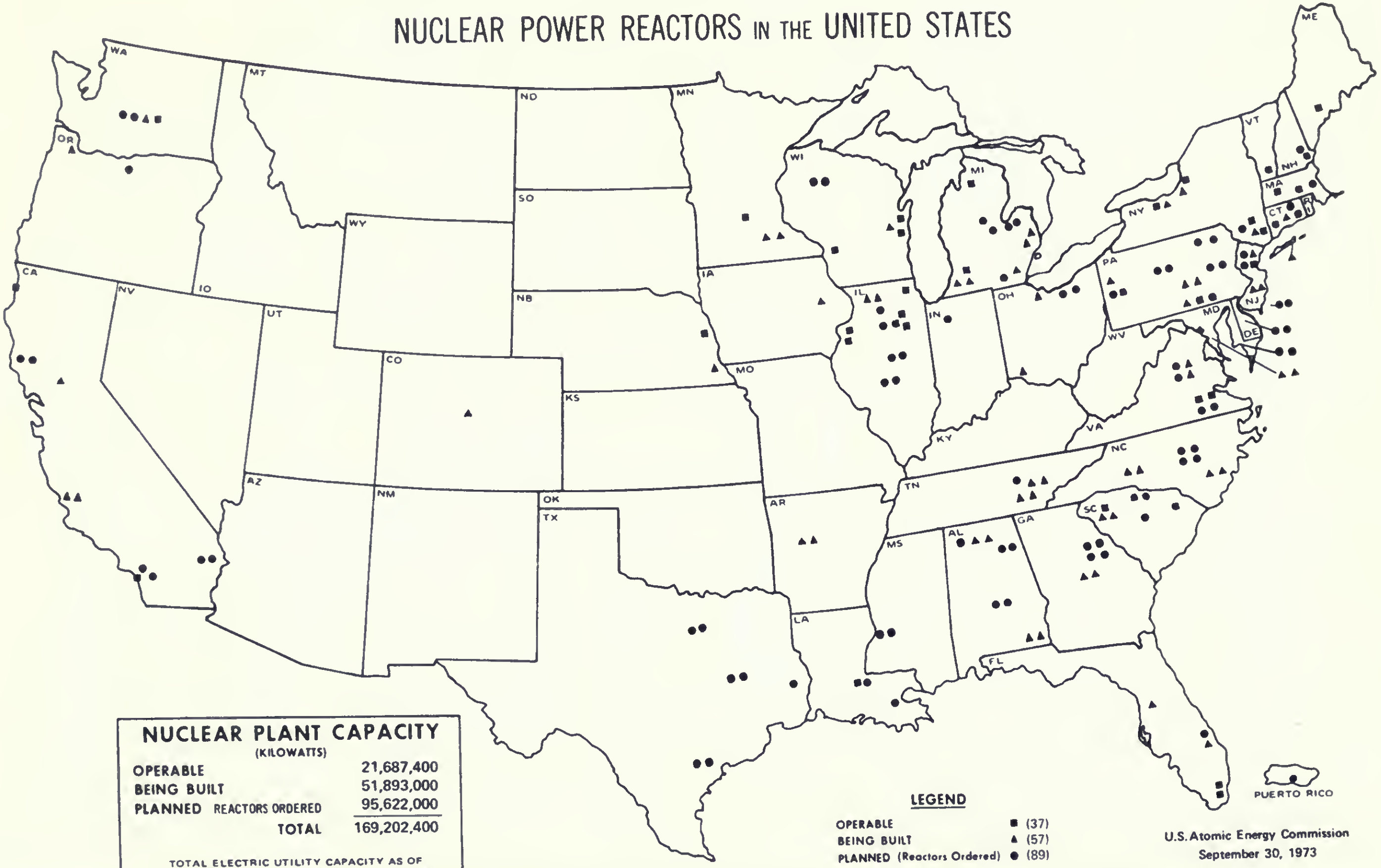


NOTE: Does not include areas of Alaska, Washington, and Oregon where some production has occurred, nor does it include potential uranium deposits where only limited exploration has been conducted

Alaska shown not to scale

Figure 19

NUCLEAR POWER REACTORS IN THE UNITED STATES



NUCLEAR PLANT CAPACITY
(KILOWATTS)

OPERABLE	21,687,400
BEING BUILT	51,893,000
PLANNED REACTORS ORDERED	95,622,000
TOTAL	169,202,400

TOTAL ELECTRIC UTILITY CAPACITY AS OF DECEMBER 31, 1972: 399,606,000 KILOWATTS

USAEC Technical Information Center, Oak Ridge, Tennessee

LEGEND

OPERABLE	■	(37)
BEING BUILT	▲	(57)
PLANNED (Reactors Ordered)	●	(89)

U.S. Atomic Energy Commission
September 30, 1973

Figure 20

POTENTIAL GEOTHERMAL FIELDS IN THE WEST

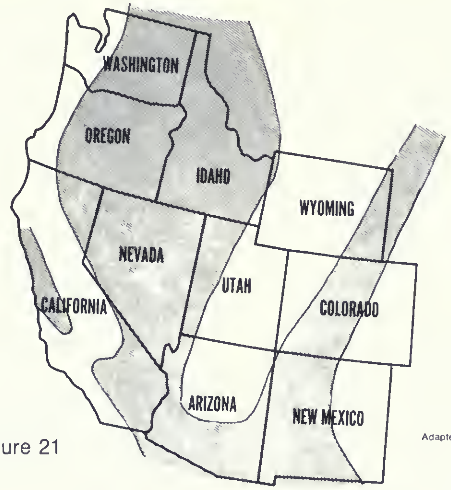


Figure 21

Adapted from Blackwell and Hall, S.M.U.

Pacific Gas and Electric Company (PG&E) is operating a hot-wet geothermal field in Sonoma County, California with good success. By the end of 1973, PG&E was producing 396 megawatts with another 106 megawatts of generating capacity under construction, for a total of 502 megawatts in the Geysers field alone.

Predictions are that the PG&E field will be producing about 1700 megawatts by the end of 1982.[12] By comparison the famous Larderello area of Italy now has a capacity of 340 megawatts and a New Zealand field now has a capacity of 290 megawatts. The cost of producing power from this field is lower than most other alternatives readily available to PG&E. In 1973, PG&E sought a rate of 8.7 mils per KWHR from the California PUC to recover their costs on a typical new well.

Similar good fortune is being sought by the Raft River PUD in Southern Idaho and Northern Utah. This utility, with Aerojet Corporation, is seeking $16 million from the Atomic Energy Commission to probe a shallow hot-wet rock deposit in the Raft River Basin. The Atomic Energy Commission has initiated funding in Idaho and has recommended a federal geothermal development budget of $185 million over the next five years. Given the right conditions private investment would probably exceed the above recommended federal budget.

The Geothermal Act of 1970 makes it possible to lease federal lands for tapping geothermal power. In the two and a half years that followed enactment, the Department of Interior has composed an Environmental Impact Statement (E.I.S.). With E.I.S. now completed the Department of Interior can lease federal lands for geothermal development. Preparation of the E.I.S. is in keeping with Section 102 (c) of the National Environmental Policy Act of 1969. Since the principal goethermal fields are under federal lands this potential energy resource has been delayed for nearly three years for lack of an environmental statement. Depending upon how reasonable the leasing restrictions are, and whether a depletion allowance will be permitted the development of geothermal power might continue to be slow.

Estimates vary on the geothermal energy potential and costs. In perhaps a typical assessment, William W. Lyons, Deputy Secretary of the Interior, recently testified to the House Science and Astronautics Sub-committee that geothermal power could provide up to ten percent of the total energy needs forecasted for the Western states to the year 2,000. This would amount to about 50,000 megawatts.

In a statement to the Senate Committee in Interior and Insular Affairs (Serial No. 93-3, part 2, page 709), John Nassikas, Chairman of the Federal Power Commission reported:

> *"The potential contribution of geothermal resources to the Nation's needs for fresh water and energy is enormous but geo-*

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[12] California's 20-year Power Plant Siting Plan, "Energy Dilemma", June 1973.

> *thermal energy is in its earliest state of technological development with particular R&D needs in the areas of resource exploration, resource assessment, reservoir exploration, development and production, utilization technology, economics, and environmental effects. Proposed federal funding for geothermal energy in FY 1973 was only about $2.5 million; an amount obviously not in keeping with the estimated potential of geothermal energy of almost 4.25 million barrels per day of oil equivalent by 1985"*

At even $4.00 per barrel the 4.25 million barrels per day would be worth $6 billion per year. Federal funding could be justified, in part, by expected return to the federal treasury by the federal land leasees of the geothermal fields. The AEC recommended budget, along with expected private funding, during the next five to ten years could liberate the equivalent of 1500 million BOE per year by 1985 mentioned by Nassikas and about 2500 million BOE per year by the year of 2000 as mentioned by Lyons.

To assure that this significant potential is realized each western state should have an individual assigned that can point out how geothermal development can be stimulated in his state. This individual should have access to high levels of government to be effective.

4.22 COAL GASIFICATION

In keeping with efforts to produce clean energy sources there has been research in recent years to refine the old methods of producing coal-gas. Previously coal-gas was primarily a product of coking ovens and used only as a process heat source. The aim now is to develop a gas with a high enough heat value to replace pipeline grade natural gas, i.e., greater than 1,000 BTU per cubic foot.

With catalytic techniques a "menthanation" process can be used to combine hydrogen and CO. By so doing a mixture of non-condensable gases resulting from heating coal with steam can be combined to form methane. The methane rich mixture would then have a high enough heat content to be of commercial interest. The efficiency of the process depends on temperature, pressure and maintaining a clean catalyst. Most all coal gasification schemes now terminate with a methanation step. The preliminary steps for handling and heating the coal account mainly for the variation among the many processes.

One of the most popular coal gasification processes known is the Lurgi process. This process dates back to 1930 but appears to be destined for a link-up with a High Temperature Gas Reactor (HTGR) in Germany. There are currently 14 plants (of up to 250 million scf/d) operating in the world today. Three such plants may be operational in the U.S.A. by 1980. When compared with the consumption rate of natural gas in the West, in 1971, it would require over forty such plants to satisfy ten percent of the demand.

The Office of Coal Research of the United States Department of Interior has been sponsoring research on coal gasification at the Institute of Gas Technology of the Illinois Institute of Technology in Chicago. The HYGAS process developed by the Institute has successfully completed over 100 successive hours of converting three tons per hour of Montana lignite into "pipeline quality gas". The HYGAS pilot plant, rated at 1.5 million scf/d was the product of a $9,000,000 project. More recently the Office of Coal Research and the American Gas Association awarded the Institute $18,000,000 for developing the steam-iron process of generating hydrogen from partially gasified coal or char.

One of the more unique processes and potentially the ultimate for reduction of sulfur content is a molten salt process developed by M. W. Kellog Co. The coal is immersed in molten sodium carbonate. In this way the high quality product is not mixed with the process combustion gases. The process, including ash removal, is continuous. Commercial feasibility of a 262 million scf/d plant has been evaluated and pilot plant proposals have been developed.

One of the major drawbacks to coal gasification is the capital expense for the processing plant. It has been estimated that a 250 million scf/d plant would cost $450,000,000. If the product costs more than natural gas and only slightly less than imported liquified natural gas the only incentive for coal gasification is one of guaranteed availability and national independence.

The AEC has recommended a federal budget for coal gasification and liquefaction of over $1.2 billion during the next five years. Total coal research with federal funds should exceed $2 billion during the next five years according to the AEC recommendations. The above recommendations for developing clean energy from coal appear necessary and warranted.

The Electric Power Research Institute has awarded a $150,000 study to the Engineering Research Institute of the University of Michigan "to determine the most economical method of converting coal into clean fuels". This, and other research programs should be expected to continue in preparation for a synthetic natural gas industry in the coalfields of the U.S.A.

4.23 OIL GASIFICATION

A synthetic natural gas (SNG) process, developed in Europe, is available for making natural gas from a wide variety of feedstock. Such feedstock might range from naptha to crude oil. The process is catalytic and not especially expensive if the feedstock is available at a reasonable price. With the scarcity of crude oil and the rising price of naptha SNG production is slow to begin in the U.S.A.

4.24 OIL SHALE

There is an estimated 500 to 600 billion barrels of oil in the oil shale deposits of the Green River Formation in the Rocky Mountains. The richest deposits are in the Colorado Piceance Creek Basin. The Utah Unita Basin and the Wyoming Washakie Basin have extensive, well mapped deposits also. In August 1973, the Department of Interior completed its environmental impact statement on oil shale development. The statement concludes that leasing of federal oil shale deposits should proceed on a test basis in each of the three above basins. The Department of Interior would regulate techniques for recovery and environmental controls. In this way both surface and underground mining techniques will be tested. In addition, both surface and underground, "in-situ", retorting will be tested. Secretary Morton of the Depart- of the Interior officially implemented the program in November 1973.

The earliest oil shale fields to be placed into production on federal land is expected in Colorado in 1978 with a 50,000 barrel per day operation. This will be followed in 1979 with a 100,000 barrel per day operation, also in Colorado. The Utah and Wyoming operations, at 50,000 barrel per day each, would be expected to follow in 1980 and 1981 respectively. If one or more of these operations proves to be an economic recovery technique it is reasonable for them to be scaled up to contribute to current and future refinery needs that accept crude oil. The current F.O.B prices for crude oil in the middle East are already well above the prices expected to be attainable from oil shale processing.

One of the more popular techniques for recovery of oil from oil shale is the TOSCO process. This process has been developed by the Colony Development Group, comprised of the Atlantic Richfield Company, the Standard Oil Company of Ohio, the Oil Shale Corporation and the Cleveland Cliffs Iron Company. Colony is currently mining oil shale on private lands. The TOSCO process introduces heated ceramic balls into a rotary kiln with crushed oil shale raising the shale temperature to 900°F, in the absence of oxygen. Excellent oil recoveries have been reported with this process in a 1,000 ton per day pilot plant. In addition, combustible gases and naptha are produced in this process.

Other recovery processes involve underground heating of crushed oil shale. This is called the "in-situ" process. The "in-situ" process is a less efficient process but potentially has a higher capacity at a lower capital cost. With the Department of Interior schedule it would be the mid-1980's before it is clear which approach is best. Commercial scale production on federal lands at that rate could not be expected until after 1985. The AEC recommended federal budget for oil shale development is less than $150 million over the next five years. Both the AEC funding recommendations and the Department of Interior schedule appear too modest to allow oil shale to significantly decrease the oil deficit by 1985. If oil shale recovery is now economic it should be pursued more vigorously.

4.25 TAR SANDS

The most impressive tar sand formation in North America is in Western Canada. The Federal Power Commission has estimated deposits there equivalent to 300 billion barrels. The Canadians have begun pilot plant processing of their tar sand deposits. The Canadian process is reported to be economic with mid-1973 oil prices.

Another major tar sand deposit exists in Utah but appears to be of less consequence than the Utah coal and oil shale deposits.

The Canadian recovery of oils from sand is perhaps five to six years ahead of our oil shale development but cannot be depended upon as a source of energy when our domestic oil sources run short.

4.26 SOLAR

There is a wide variety of ways suggested to harness our greatest energy source of all -- solar radiation. Capture mechanisms range from cultured tree lots to photovoltaic cells. Even efficiencies as low as one percent would appear attractive from a fuel-cost viewpoint but the capital costs are also important. In desert areas where the system is solely for the purpose of heating water the capital cost can be low. When semiconductors and reflectors are utilized to generate electricity from solar radiation the capital cost is exceedingly high.

The clear skies of the western states provide an edge in the utilization of this energy source. Therefore, more research and demonstrations in this field are warranted in western universities.

Greater utilization of solar radiation especially for creature comfort appears justifiable at this time. Solar energy can be delivered directly to the user leaving the user to decide on whether he wants to manage and utilize this abundant and renewable resource. Several concepts for home heating using solar radiation have already been demonstrated. Continuing development is justified for refinement and then a financing program may offer widespread use. As a domestic heat source solar energy can use an electric "helper-system" for extended cloudy periods. The added capital investment to justify a dual system will need to follow an increase in other fuel costs or very low interest financing. The extension service of the land grant colleges could be a good institution for assisting in the introduction of this form of solar energy collection.

Converting solar energy into electricity will probably remain non-economic due to high capital expense. Although more research is needed in this field little reliance can be placed on economic utilization of solar energy for the production of electricity.

A practical approach that is available at this time is to take advantage of the photosynthesis process of producing carbohydrates from CO_2 for subsequent use as a fuel. Utilization of this form of energy can be through the use of forest residues and by the deliberate production of wood for fuel. Most states are empowered to regulate the manner in which wood residue is burned but few have encouraged energy recovery from the residues with grants or demonstration contracts. A demonstration project is the most convincing way to initiate widespread use of resource recovery systems.

The AEC recommendation for federal support of solar energy R&D amounts to about $200 million during the next five years. Since the major benefit can come from home heating, private investments should probably account for a larger expenditure than the federal.

4.27 FUSION

Fusion is expected to be of little value as an energy source for the remainder of this century. If fusion can be sustained with deuterium and if the process can be contained in an engineered structure, a limitless store of energy would be available. If even the simpler fusion reaction can be sustained, controlled and contained using less-abundant tritium, a vast quantity of energy could be added to our available resources.

Over $150 million is being spent worldwide in fusion research. Recent developments in the United States using a laser beam on a pellet of deuterium- tritium have resulted in a burst of fusion energy and may have advanced fusion development by five years, according to Representive M. Price, Chairman of JCAE. The U.S.S.R. scientists have also been encouraged in recent years. However, even though a working controlled fusion process is demonstrated there is no assurance that it can be used to generate electricity because of possible high temperature materials limitations.

Continued research is clearly warranted but to depend on fusion in our power planning before 2000 would be unrealistic. Proceeding with a design of a power station using the fusion process will help to resolve the capabilities of known materials to contain such an energy source. If high neutron dose rates become a limitation it is not too early to start materials testing in fast spectrum reactors or accelerators.

The AEC recommended federal budget for fusion is almost $1.5 billion over the next five years. This heavy emphasis is based on recognition of the need to use more non-depleting energy resources and also upon encouraging progress with fusion during this past year.

4.28 HYDROGEN

Hydrogen can be generated in a variety of ways, chemical, electrochemical, etc. As a fluid, hydrogen is considered by some as a fuel that can be transported without dependence on transmission lines. Central station production of hydrogen from water could thus provide a fuel for transportation, fuel cells, etc. With fusion as an energy source a "hydrogen economy" could someday evolve.

Use of hydrogen in fuel cells is not yet an economically attractive alternative for the production of electricity but is being tested on a small scale by some of the more progressive utilities.

4.29 WINDPOWER, TIDAL, ETC.

A variety of gadgets, schemes and contraptions can be used to generate electrical power. Indeed many are used in situations where electrical power is not available. To expect such hardware to start to satisfy the growing needs for electrical power in the West is to miss the magnitude of the challenge.

In addition to the scale of effort, reliability is needed in a power grid. Small scale energy installations generally distract from the establishment of a reliable grid rather than add to it. Small-scale hardware that are also subject to meteorological variations cannot be considered useful energy resources.

5.0 ENERGY PLANNING

Electrical generation generally is based on sources that are indigenous to the region served. As previously cited the West has generally relied upon hydro power for electrical production in the past whereas the East has relied mostly upon coal. The future choices of energy in the West will differ now that most of the favorable hydroelectric sites have been developed. The shift in resources can be viewed in three timeframes as shown in Table 12.

5.1 NEAR-TERM

Between now and the end of 1974 is a critical period. It is a time when energy resources must be planned for the following decade - a period in which to prepare for national energy independence. The same period will be one of restraint to avoid overcommitting the already marginal energy reserves.

Throughout the West construction of generation resources has been slow, during the past six years, pending resolution of environmental legislation and guidelines. In particular, the construction of new nuclear power plants has been slow to accommodate public involvement. Slowing nuclear power plants in the face of increasing energy demands has forced utilities to increase their consumption of fossil fuels, particularly coal. Where it has not been possible to burn additional fossil fuels within their own region the utilities have gone to regions which have fossil fuels and which welcome industrial growth.

When enough **Environmental** control is assured to let strip mining proceed it should be possible to provide a strong thermal power base to complement the hydro peaking that is already installed in the West. The environmental degradation resulting from strip mining and increased burning of fossil fuels can be reduced with advancing technology and with energy conservation. Both are essential during the next seven to twelve years to avert more public outcry and create serious electric power system failures in parts of the West.

With recent trends towards larger generating plants the reserve margin would normally need to be increased. However, with the 60,000 megawatt interconnected grid throughout the western states, increments of 1,000 megawatts required less than a 20 percent reserve margin as shown in Figure 22. If each state acted independently, the economic 1,000 megawatt units might require reserve margins of 35 to 40 percent. The projected reserves in the West are shown in Table 13. Only if all construction schedules can be met will the reserves be as comfortable as shown. By reviewing Tables 9 and 11 it appears that the period of 1977 - 1979 may be especially difficult with respect to maintaining regional generation resources growth.

During the near-term there should be a strong effort to shift from natural gas and oil to other available fuels for electrical generation. This effort should then be followed by another effort to replace all oil fired plants with coal and uranium during the transitional period. To accomplish the near term-shift from gas to oil our domestic production must be im-

Table 12

ENERGY SOURCES AVAILABLE AND THAT CAN BE DEVELOPED

FOR ELECTRICAL GENERATION

Near-term 1973 - 1974	Transitional 1975 - 1985	Long-term 1986 - 2000
Gas	----	---
Hydro	Hydro	Hydro
Oil	Oil	---
Coal	Coal	Coal
Uranium	Uranium	Uranium
---	Geothermal	Geothermal
---	---	Oil Shale
---	---	Breeders
---	---	Solar

proved immediately with more offshore drilling and by construction of at least one trans-Alaska pipeline.

Imported oil has been one of the cheapest sources of energy to U.S. industry in the recent past. The nation may have been wise to use imported oil in preference to more rapid depletion of its indigenous resources, however with the present national goal towards energy independence, the nation must carefully execute an oil conservation plan. This has been started in the near-term and must be completed in the transitional period. It can be done with a national energy program involving less use of oil in steam-electric plants and greater production from oil shale.

To recover the indigenous oil in shale it may be necessary to sacrifice a canyon or two near the Green River Formation. The sooner production of oil from oil shale can be made into a commercial reality, the sounder will be the energy base of the nation. A workable and stable oil conservation program may take 10 to 15 years to be complete but is a necessary prerequisite to independence from foreign imports.

With increasing costs of energy in all forms and with a public desirous of minimizing environmental abuse, response to conservation efforts is needed in the near-term. However, conservation efforts will not replace the need for building new generation facilities. Such facilities are needed to maintain the economy of the region and to continue our shift to electrical power as a form of cleaner energy for industrial, commercial, and residential use, as well as for environmental control equipment.

REQUIRED ELECTRICAL GENERATION RESERVES FOR VARIOUS SIZE GRID SYSTEMS

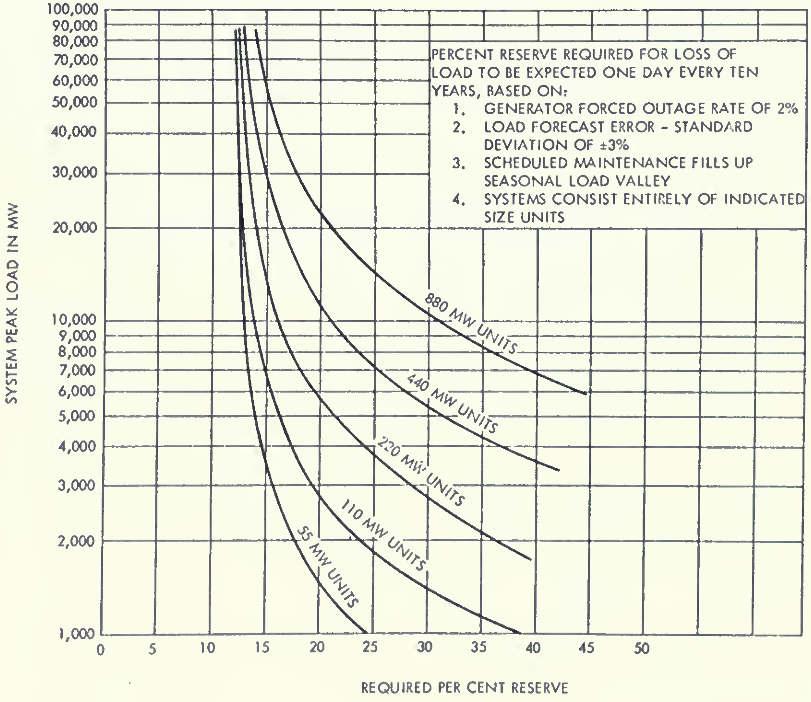

Figure 22

5.2 TRANSITIONAL

There will be a period between 1974 and 1985 in which electrical power from coal and uranium must become sufficiently available to meet the base load energy needs now filled by gas and oil. Coal has been neglected in past years due to the low cost of natural gas and hydroelectric power. The present hiatus is an ideal time to reinvestigate alternative energy sources as listed in Table 14. Legislatively geothermal power is ready to proceed. All of these alternatives could benefit with more federal R&D funds. Each source was described in more detail in Section 4.0. Grossly increased federal funding appears imminent.

Other substantial efforts should include the development of synthetic gas and oil from coal, solid wastes, etc. These fuels can be shipped by pipeline to load centers. Some will be available as synthetic natural gas which is essentially equivalent to natural gas. Other of the gases may have such a low heating value that they will be used at the retort site.

Technically the aim is not to replace a fuel that can be burned at the minesite (such as coal) but to produce feedstock for the petrochemical and natural gas industry. A strong move to generate synthetic fuels will strengthen the economy of both the West and the Nation.

The timetable in which synthetic fuels can be availabe from oil shale is probably in the late 1980's. As currently planned, the early 1980's will be concerned with oil recovery by various retorting schemes on test-lease sites selected by the Department of Interior. With success, additional federal land will be leased and larger plants built.

Despite enthusiasm for synthetic fuels it appears that the production rate will be limited by investment funds throughout the transitional period. Release of more federal lands could stimulate the necessary investment.

There have been estimates of the fraction of electrical power nationally that will result from nuclear energy at the end of the transitional period. Such estimates generally range from 30 to 50 percent. By that time coal in the West will probably constitute a like amount despite the rapidly increasing costs of coal-fired plants. The hydropower that characterizes the West today will most likely remain fixed and reach a smaller and smaller fraction of the total by 2,000 A.D. Unless there are some technological breakthroughs, the transitional period will result in the emergence of synthetic fuels, geothermal power and an increasing use of nuclear power and coal.

Table 13

1972 WESTERN SYSTEMS COORDINATING COUNCIL ELECTRICAL LOADS AND RESOURCES ENERGY FORECAST 1973 - 1982

August	Firm Loads	Net Resources	Surplus	Reserves
1973	42,553 MW	51,444 MW	8,891 MW	20.9%
1974	45,750	56,077	10,326	22.6%
1975	48,796	60,501	11,704	24.0%
1976	52,179	65,234	13,055	25.0%
1977	55,728	69,435	13,706	24.6%
1978	59,580	73,953	14,372	24.1%
1979	63,582	79,812	16,229	25.5%
1980	67,715	84,938	17,222	25.4%
1981	72,215	90,879	18,663	25.8%
1982	77,260	95,878	18,617	24.1%

*includes provision for scheduled maintainence and adverse water condition and presumes new generation resources to be completed on schedule.

5.3 LONG-TERM

As C. Starr observed in 1971,

> *"If the only energy resource in sight were fossil fuel, the prospect would be bleak indeed. The outlook is completely altered however if one includes the energy available from nuclear power".*

The "long-term" here is considered 1986 to 2000. We have seen from supply curves (Figure 4) that some of our major gas and oil production in the West will be significantly depleted by 1985. It can be predicted that other energy sources such as nuclear construction will accellerate through 1985. It can be predicted that other energy sources might also be available by then, but it is unlikely that energy sources other than those tabulated in Table 12 will be available in any significant volume at that time. By 1985, others, such as fusion may have a date for prototype development and solar power will probably still be used only to warm water. Tidal power and wind power will probably continue to be considered but less able to keep up with the growing energy demands of the West.

Table 14

CATEGORICAL LIST OF ENERGY SOURCES

Depletable

- Fossil fuels
  - Coal (including gasification and liquefaction)
    - Oil
      - Petroleum liquids
    - (including gasification of naphtha and residual oils)
    - Oil shale
    - Tar sands
  - Natural gas
- Nuclear energy
  - Fission
  - Breeder reactor
  - Fusion
- Geothermal energy
  - Steam
  - Hot water
  - Hot rock
- Other

Renewable

- Solar energy
  - Low intensity sources
  - High intensity sources
  - Photosynthesis
- Tidal energy
- Wind energy
- Hydroelectric
- Organic solid wastes
- Nuclear energy
  - Breeder reactors

At the present time it appears that the long-term electrical generation needs of the West can best be met by nuclear energy. Beyond 1985 siting more of the nuclear power plants within the coastal states should be possible leaving the coal-fired generation facilities being built in the Rockies to meet the growing needs of the mountain states and the Great Basin.

It is expected that by 1985 there will be a complete resolution of safety standards and waste handling systems for commercial nuclear power plants. Until these matters are fully resolved and explained the long-term reliance on nuclear power cannot be assured. When these two points are resolved, more complicated cases such as nuclear breeders and fusion plants can be approached. WINB and the member states have a significant role to play in conveying information on nuclear power to the public.

Long-term planning should embrace the fact that natural gas and oil are too precious to burn in electrical generation plants except for special circumstances. As shown in Figure 1 the scale of energy consumption in the West beyond 1985 is expected to be nearly double the current rate with an increasing amount going to electrical power consumption. The increased scale of energy needs and the decreasing number of fuels makes it clear that nuclear power must be prepared to accept an even more major role beyond 1985. Estimates for the year of 2000 show that the portion of electrical generation attributable to nuclear power will be between 40 and 60 percent. If 50 percent is the correct number then it has been estimated that 1,000,000 megawatts of nuclear generating capacity will be needed in the U.S.A., by the year 2000, of which 150,000 megawatts will be needed in the West. Figure 3 shows that the West has historically kept pace with nuclear power generation in the balance of the U.S.A. (i.e. 17 percent of the nation's population using 16 percent of the nation's nuclear power). If the West continues to consume 15 percent of the national energy demand by 2000 and if the West maintains its current pace on choice of nuclear power, then it may be assumed that the West should be prepared to build 150 nuclear generating units at about thirty different sites.

By examining Figure 1 the West will require the equivalent of 1800 million BOE per year, 1990, for electrical generation. According to the Federal Power Commission in 1970 (Figure 5) about 74 percent of the electrical generation in the West will be from a combination of coal and nuclear power by 1990. Of the 74 percent the nuclear portion is expected to account for 57 percent.

For a variety of reasons (inculding lead-time requirements) the trend has been the opposite to date with coal fired plants being installed at a rate of 2:1 over nuclear plants. This trend is expected to continue to 1980 and then to begin to swing more heavily towards nuclear units. If half of the 74 percent is nuclear it may require 20 sites for 54 nuclear units of 1,000 megawatt rating by 1990; and a like number for coal. Even before 1990 it may be necessary to ship coal from the Rockies to areas with more cooling water available to maintain the above pace.

If 54 nuclear units are installed in the West by 1990 it is easier to see how 150 units could be installed by 2000 A.D.. It is expected that sites chosen beyond 1985 will all be multiple unit sites and those beyond 1990 capable of handling at least four 1,000 megawatt units.

The prospects of licensing 1,000 nuclear power plants in the next 27 years makes it clear that the federal system that has licensed 38 plants in the past 16 years needs to be considerably streamlined. In 1972, 33 nuclear power plants were ordered and only eight operating licenses granted nationally. Between 1985 and 2000 an average of over 30 nuclear plants per year will need to be licensed. The time to begin the streamlining effort would appear to be overdue. Statements by Commissioner Doub have pledged his efforts to reduce the current ten year licensing sequence to six years. This would be accomplished through a combination of a standardized design for the nuclear unit and prior site certification by the states. If accomplished, the six year sequence could permit the long-term stable energy economy in the West before 1985.

5.4 STATE COMMERCE GOALS

In a nation composed of individual states each state has an opportunity to evaluate and formulate **its** commerce goals. Energy can be used as a commodity to meet these goals. For the states that want to compete as energy-export states they need to decide whether they want to exploit their natural resources now or at a future date and at what price environmentally. For the energy-import states, decisions should be prearranged of which industry will be dropped first in periods of short energy supply in the region.

State governments can influence the destiny of the individual states. State governments can best reflect the will of the citizens within the state and can best exercise the options open to its citizens there. Within limits the state governments can face the task of deciding whether they want to be an energy export or import state, by so doing energy planning by groups such as the Western Interstate Nuclear Board can proceed in a more effective manner.

There is much to be said for the utilization of natural resources within the western states to meet the energy needs of the nation and the commerce needs of the states. Alaska expects energy export to be the No. 1 business in the state followed by tourism. In many cases, properly controlled extraction of energy resources can be accomplished even without visual impact to an observer on a nearby road. Comparable scales of commerce would frequently crowd the population centers of the West where further growth would be less justifiable.

6.0 ACTION NEEDS FOR WESTERN STATES

The Western states have a role in meeting the power needs of their own states, of the region and of the nation. Since most of the energy resources in the West are on federal lands each state should expect to become a participant in some way in the national search for new energy resources. Alaska may be an exception to the rule in that the energy-rich lands there are mostly on state lands and subject to royalty payments. It is possibly due to this improved position that Alaska welcomes utilization of its vast oil, gas and coal resources. Other states, such as Idaho, have witnessed sufficient decrease in its salmon population that it would prefer to not tap any of the remaining 90 percent of its hydroelectric potential. California is typical of many populous states in that it is already too populated to conveniently become a net exporter of energy. This situation creates the opportunity for energy commerce in other states. New Mexico, Wyoming and Montana are considering exploitation of their indigenous coal deposits at a record rate but not before assurances are granted that the associated environmental disruption will be restored.

Each region has a role in meeting the energy needs of the nation. The following sections are a suggested collective role for western states.

6.1 ENERGY CONSERVATION

The region and the nation are being placed in a compromising position for lack of adequate energy reserves for the winter of 1973 - 1974. In this winter and the following one the region appears low on natural gas, heating oil, gasoline and electrical power. The time required to build new refineries and to build steam-electric plants is long (five to ten years). Additional sources of energy such as geothermal have thusfar been delayed two and a half years with federal paper processing and evaluation. The trans-Alaska pipeline has been delayed in the courts for two years. Refinery construction in the U.S. has not kept pace with increasing demands and the construction of nuclear power plants has been delayed for lack of public acceptance and by production difficulties. In addition, federal support of oil shale development and coal gasification has been small.

The above difficulties, together with the ever-increasing demand for electrical power, have reduced our generation reserves to a point that there is only one prudent course to follow -- conservation. Energy conservation is needed at home, at work and in commerce. In the past, various parts of the West have been able to supply power to meet the critical needs of another region. The winter of 1973 - 1974 finds the West region with little flexibility. Blackouts are possible even in the Northwest.

In what form should the conservation effort be? The Northwestern states were stimulated to find answers to some of these questions following the lightest rainfall in 94 years.

The Western Governors have collectively recognized[13] that energy conservation is essential and each has appointed a senior staff member to an energy task force for regional recommendations on conservation, allocation, etc.

who?

Table 15 has been prepared as a format for an energy conservation checklist. It is by no means complete. Many of the points listed must be performed collaterally among the western states.

The conservation steps all sound simple enough but many take months and years to perform. Voluntary reductions have traditionally been found to be worth three to ten percent. If consumption needs to be cut back further, the state government should intercede on behalf of the utilities with mandatory reductions. A curtailment by the state is felt to help avoid legal difficulties since the state would have previously ordered the utility to provide sufficient power to its district.

At a historic September 7, 1973 meeting of the Council of Governments of the four Northwestern states, eight guidelines were formulated to prepare for the possibility of mandatory power curtailment. They are:

1. Curtailment need is to avert an electric power system failure.
2. Curtailment must be on a regional basis. Individual state action will not be effective. Regional action can be accomplished by simultaneous and parallel state action in the parts of Washington, Oregon, Idaho. and Montana served by the N. W. Power Pool.
3. A specific and distinct state government curtailment authority should administer the curtailment.
4. Any curtailment law or allocation directive should apply to all users of power in a state regardless of source of power supply.
5. State government decision - not utility decision - should invoke and administer curtailment.
6. Strong input from utilities and citizens is advisable because the situation can improve or deteriorate quite rapidly.
7. Utilities should be used to implement curtailment orders but protection of the utility against liability claims should be provided.
8. To accommodate item 2, instruction should be given to the appropriate agency in every state to communicate with similar authorized agencies in other states and, as much as possible, work for similar action in other states.

To avoid the panic of annual involuntary controls an orderly conservation program will be needed until at least 1980. Energy conservation makes good sense even with additional available resources. Certainly, without the needed resources, there is no choice other than to pursue a policy of energy conservation.

6.2 ENVIRONMENTAL PROTECTION

The environmental impact of generating electrical power is automatically negative to some persons by their recall of a photo or an experience with a smokestack. The efficiency with which fuels are burned in modern plants and the many benefits derived by the generated power are seldom measured in the "judgement" of environmental impact. When measurements are made it can be shown that stack control devices now remove over 95 percent of the flyash from coal plants and may soon be removing 99.5 percent. It can be shown that the use of cleaner fuels has substantially reduced sulfur oxides that had previously fouled the air. In many areas of electrical power generation the emphasis has been on reducing environmental impact even further.

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[13] Western Governors Conference, September 1973, Salishan Lodge, Oregon

Table 15

CONSERVATION MEASURES

	Near-term	Transitional	Long-term
Transportation	Lower speed limits, rationing, price increase to cover needed investments.	Tax incentives to reduce auto weights, rapid transit planning, revise truck weight and length limits.	Rapid transit construction, more efficient engines.
Industrial & Commercial	Direct appeal for conservation and use of energy consultants, reduce outdoor lighting.	Restructure rate schedules, effect greater conservation and recycling.	Product planning base on energy limits, employee incentive programs.
Residential	Create awareness of consequences, prepare for consequences, require better insulation standards, lower thermostats.	Restructure rate schedules, use heat pumps and solar energy collection systems.	Possibly ineffective except by severe increases of energy rates - which may be in effect by then, utilize solar energy for home heating where appropriate.
Government	Establish priorities for allocations and possible rationing, release lands for geogeothermal power production, expand supportive R&D efforts on new energy source.	Encourage conservation and recycling of energy consuming products, encourage energy related R&D on converting wastes into fuels, consider uses for waste heat from power plants.	Provide for industrial production using federal R&D, assist industry in conducting R&D leading to greater efficiency in production and transmission of power.
Utilities	Advise public of seriousness of inadequate reserves, educate public on how to conserve power, seek legislative assistance for mandatory curtailment program.	Establish strong interregional interties, burn fossil fuels as required to maintain reliable grid systems, seek to establish an adequate number of nuclear power plant sites to meet future energy needs.	Maintain extensive R&D program towards fusion, breeders, transmission, etc.

Nuclear power plants are especially well adapted for being a clean source of power. With a minor amount of effort, nuclear plants have reduced their radioactive discharges by factors of ten and have abated most of their warm water discharges with cooling towers and ponds. Further efforts to reduce the environmental impact of power plants would be at a high cost and possibly not a justifiable expense in view of other societal needs.

Attention has been turned to the environmental impact of those plants that will produce synthetic fuels for domestic and industrial use. Such plants can produce energy in a form for home heating that is much less abusive environmentally, than burning coal in residential units. Even though such production may not lend itself to metropolitan siting it has a strong role in providing clean energy for the West.

There are two fundamental observations that can be made at this time, they are:

1. That the increasing use of electrical energy in our society has been beneficial environmentally, especially in our urban areas.
2. Nuclear power plants are environmentally the cleanest developed energy source available to us today for satisfying the growing demand for electrical power.

The second observation is made with a high degree of confidence that warmed condenser coolant water can be cooled before it is released and that nuclear wastes can be safely stored. Both history and current efforts support these qualifications.

6.3 ENERGY RESOURCE CRITERIA

Criteria for development of energy resources include the following:

1. Adequacy
2. Reliability
3. Economics
4. Environmental Impact

To be considered a significant energy resource the energy source needs to meet a significant share of an energy grid system. What may be significant to a small public utility district may be much smaller than it would take to interest one of the nation's large private utilities.

Adequately meeting the demands of a district is a requirement that a utility agrees to in receiving a franchised area. The decision of whether a utility needs a nuclear plant or a windmill to adequately meet its generation resource needs should rest with the utility. Likewise, utilities should have a voice in assigning priorities to new generation resource needs. Establishment of the Electric Power Research Institute is a good example of facing the future research and development needs of the industry. The institute is funded by utility revenues and directed by utilities to develop new generation resources and transmission technology.

Reliability is just as fundamental an issue as adequacy. Energy resources are all considered undeveloped until they can be tapped in a reliable manner. To go from the spinning reserves of hydroelectric stations to the uncertainties of a solar energy system may tax the ingenuity of the most resourceful of the utility technicians. Considerable progress has been made in the past two decades in improving the reliability of electrical grids in the West. Much of the improvement is a result of interconnections between utilities and between regions. The High Voltage Direct Current line from the Northwest to the Southwest is the most noteworthy intertie of the decade in the West and perhaps in the Nation.

The West is interconnected with what is known as the "Western Loop" as shown in Figure 23. Utilities in eleven of the twelve WINB member states belong to the Western States Coordinating Council (WSCC). The prevailing self-reliance of WSCC has been structured since its formation in 1967. It now serves 36 million persons with over 60,000 megawatts. With the current grid flexibility it would appear that a wide variety of energy resources could be accommodated reliably in the western region.

The cost of electrical power generation had been decreasing for the 50 years preceding 1970 due to the economy of scale in building larger generation units. Federal hydro projects have also helped to keep electrical rates low in the West. With the advent of thermal power plants the electric generation costs will reflect higher construction and fuel cost. The rate rise will not necessarily rise in proportion to fuel costs but will be strongly influenced by them. This new situation will give rise to consideration of new fuels. For example, recovery of oil from oil shale has not been economic in the past. With massive equipment and a new market scene it may become economic in the next 10 to 20 years. Stimulation of natural gas bearing rocks also has not been economic as long as natural gas was available in the oil fields. When paying the high price to import natural gas, nuclear stimulation may again be seriously considered. The advantages expected by stimulation of gas-bearing rocks near Rulison, Colorado is shown[14] in Figure 24.

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[14] "Project Rulison and the Economic Potential of Nuclear Gas Stimulation", B.G. Bray et.al., CER Geonuclear Corporation, Las Vegas, Nevada, 1970.

ELECTRIC TRANSMISSION IN THE WEST REGION

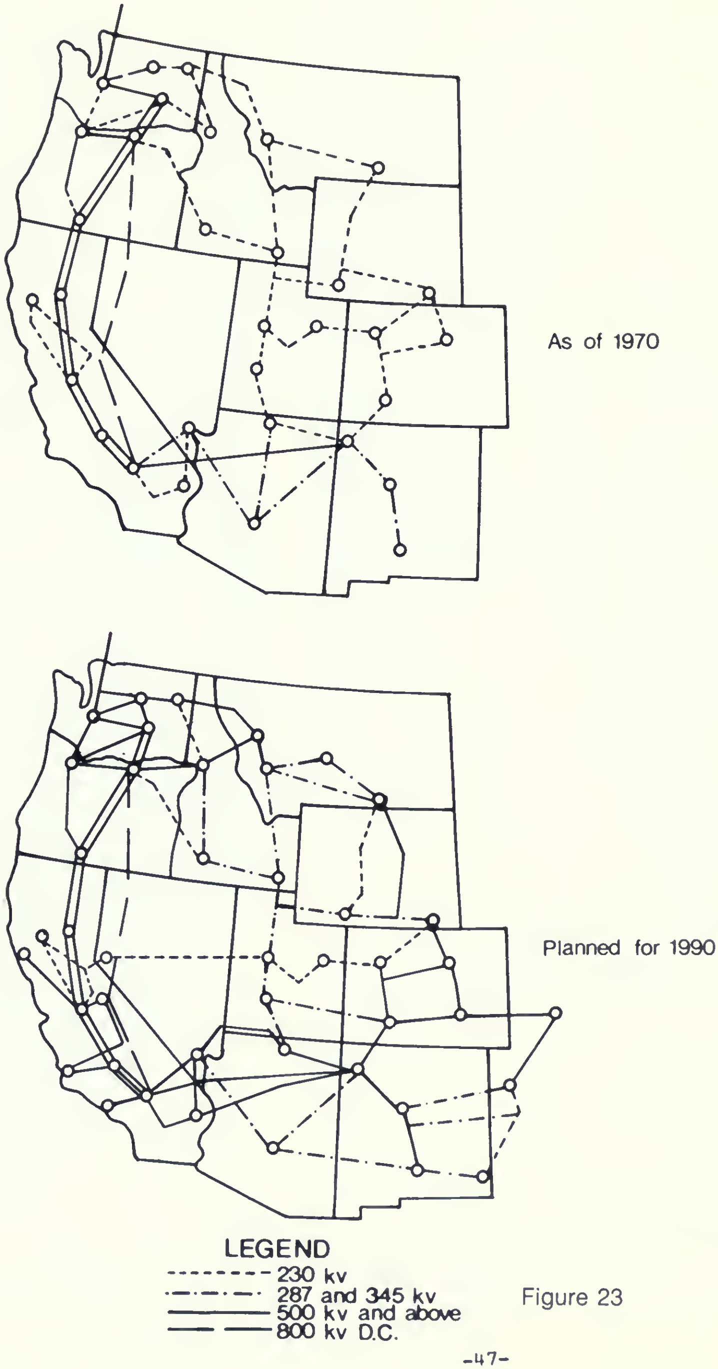

Figure 23

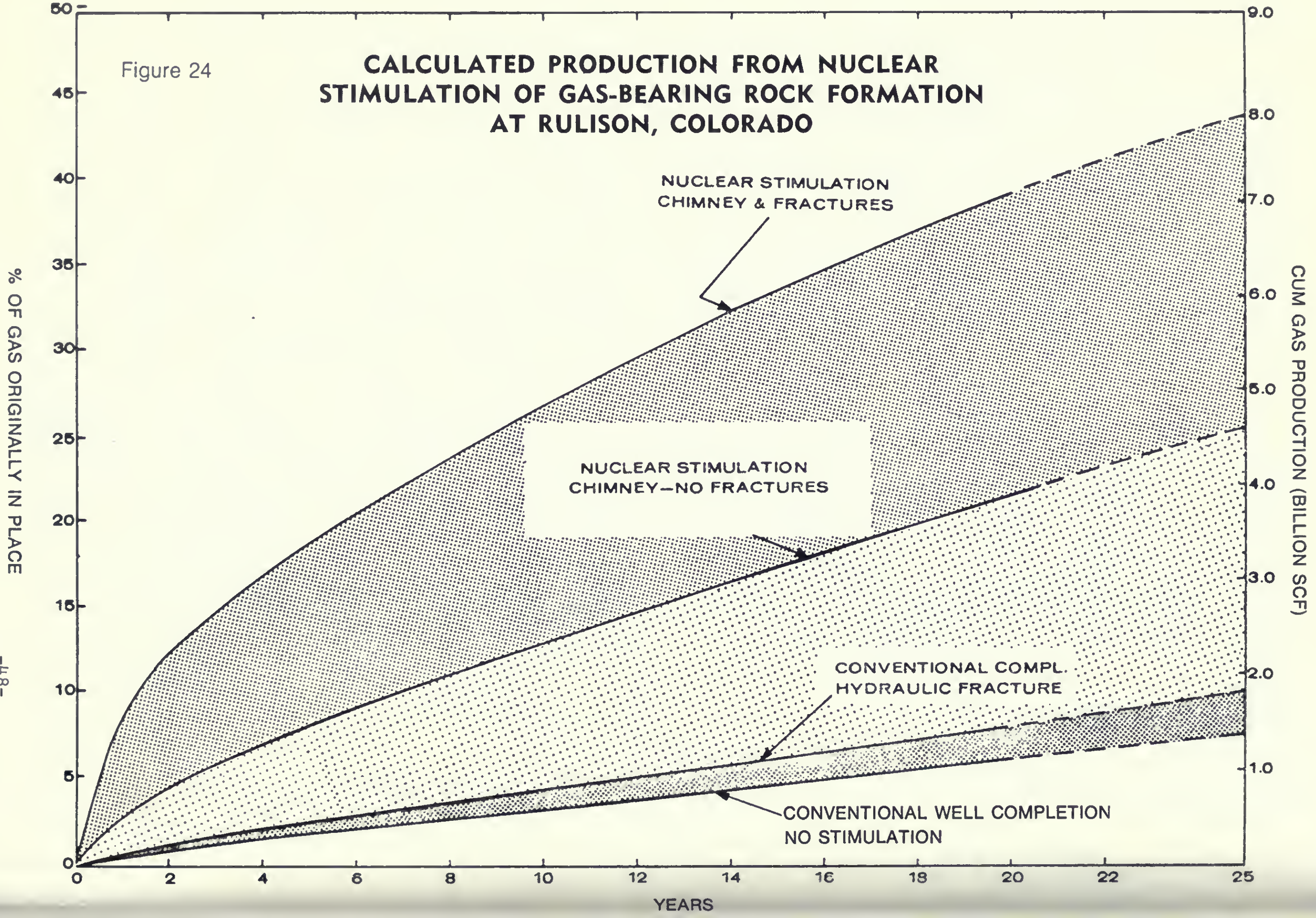

Figure 24

CALCULATED PRODUCTION FROM NUCLEAR STIMULATION OF GAS-BEARING ROCK FORMATION AT RULISON, COLORADO

A higher value on natural gas will permit longer storage underground, which in turn will assist in reducing the residual radioactivity.

The environmental impact of the industry which transforms energy resources into a useable form must be measured just as any other chemical or manufacturing industry. For some processes, such as refineries, it may be difficult to meet certain clean air standards. For nuclear power plants generating electrical power the principal difficulty has been in controlling the warmed effluent from the turbine condensors. The full cost of meeting environmental standards must be included before the economic feasibility is judged.

The final criterion, resource depletion, is of obvious concern to an industrial nation with a growing economy.

6.4 STIMULATING ENERGY RESOURCE DEVELOPMENT

The Western states have been fortunate in having sufficient natural resources available to meet most of their energy needs. The next twenty years, however, may call for a doubling of the energy demands and there are a decreasing number of traditional possibilities left for satisfying the growing needs. This situation suggests that the western states should establish new incentives for energy resource development. By examination of the natural resources of the several Western states it becomes clear that development incentives in each region of the West may be different. The Rocky Mountain states have coal and oil shale from which to develop gas and oil. The Southwestern states are the most natural region of the U.S.A. to exploit solar energy to the fullest. The Western states are underlain with potentially significant geothermal resources. The coastal states have sufficient load centers and cooling water to justify development of a nuclear-based energy grid backed up with pumped storage for peaking.

Therefore, each region may require a different set of incentives to develop its energy capabilities. With adequate interconnections it is not essential that each state become self-reliant. In fact, some states (e.g. Alaska) are most anxious to use their energy resources as a commodity. Since power production is a capital intensive industry, the state governments (through taxation and regulation) can have a large impact on the feasibility of energy resource development within their states.

In some cases the states can benefit remote and economically depressed areas of the state by siting of power production facilities and refineries there. If the states are involved in establishing emission standards they can influence the location of such facilities with less stringent emission standards away from the metropolitan areas. Air quality standards which would require the same emission standards in metropolitan basins as in windblown desert areas are counterinducive to development of the West and of our energy resources.

A rise in the interstate price of natural gas would be one of the greatest incentives for development of new energy sources and is a change that could be implemented almost immediately. The traditionally low prices for natural gas have led to energy wasteage but even worse have not permitted viable alternatives to be marketed.

Incentives for capital investment generally follow technological and/or legislative advances. Stimulation of capital investment in energy development can also follow a shift in economics. The states can help to stimulate action using any three of the above.

The development needs were listed in Section 4.0 for each of the more promising new energy sources. Institutional arrangements for accomplishing the above can remain virtually unchanged; although in some cases the administrative procedures need to be streamlined.

6.5 ENERGY R&D—STATE'S ROLE

The subject of energy R&D is getting increasing attention as citizens want to become more involved in the decisions that effect their lives. State and local governments are a likely forum for the airing of issues that relate to energy development and use. Therefore, the state is not without a role in helping to foster certain energy-related R&D progress.

The highly technical and the economic feasibility studies perhaps best fall within the domain of universities and industrial groups. Impact studies, however, are a form of R&D that is best done by those closest to the socio-economic needs of the public. For example, if the environmental and socio-economic impact of building a series of power plants in a particular area is beneficial, the state may want to encourage such multiple plant siting. If, on the other hand, the impacts from developing sites are adverse the state and local government should be prepared to specify requirements as a condition to the development.

States should be equipped with energy development or power plant siting legislation, and an assessment capability under which the state can conduct or order adequate impact studies. PUC funding can also be used to study alternative forms of power other than what is proposed. Another source of R&D funding by the state can be through pollution control bonds.

States can make it easy or difficult for energy production facilities to be located within their boundries. The extent to which emissions are or can be reduced with R&D funding often affects a state's interest in receiving a particular production facility. Therefore, R&D in the energy field is of serious interest to the states. A staff or staff member that can advise each governor and the appropriate state agencies regarding energy production should be established in any modern state government.

6.6 PRIORITIES IN ENERGY DEVELOPMENT

With the high cost of developing new energy resources care must be taken to avoid expending a major fraction of available funding on developing systems that have slim chance of providing a commensurate return. Also, the concept of developing diversity in the nation's energy mix is essential.

The four basic forms of energy requirements are described separately.

(1) Transportable

The supply of fuels such as gasoline may be short for several years. A high priority program to reduce the gasoline needs of the nation is warranted in view of the significance of the drain that automobiles extract on our available resources. A priority shift towards mass transportation and advanced propulsion systems such as electric autos may be warranted at this time. Pollution control equipment for autos should be optimized for energy efficiency as well as emission control.

(2) Electrical

Electrical power production in a modern industrial and highly technological society desirous of maintaining a high standard of living should never be short or even threatened. A very high priority is needed to restore generation reserves using several electrical generation resources. Fossil fuels (especially natural gas and oil) should be displaced as soon as possible due to their higher priority need elsewhere. Hydro (as peaking power) and nuclear power are both candidates for future, high priority, development as substitutes for fossil fired electrical generation plants. Development of breeder reactors in the U.S.A. should continue to receive a high priority due to their ability to extend our fuel availability base. Convertor reactors and use of plutonium in thermal reactors should receive a commensurate amount of priority for the same reason. Use of coal and wood residues to restore electrical generation reserves in the near-term also deserve a high development priority.

(3) Heating and cooling

Heating and cooling can be done in residences and businesses in a variety of ways. Greater use of insulation and timely (diurnal) ventilation are probably the least expensive. Capturning the sun's rays into a black, water-filled collector and insulated tank is like-wise inexpensive. Such solar collection systems when available, will undoubtedly become popular quite rapidly as the cost of natural gas and electricity rises. Development and demonstration of solar energy collection systems for residential heating should receive a high priority.

Development and demonstration of solar energy collection systems for residential heating should receive a high priority.

Geothermal power could be used directly for heating and to generate electricity. When used to generate electrical power geothermal power sometimes needs to rely on low boiling point organic fluids to achieve a reasonable efficiency. Although some priority should be given to geothermal power for electrical generation it should also be considered as a basic process heat source.

(4) Chemical availability

Chemical availability is essential in maintaining an industrial society. With the decreasing availability of certain petrochemicals, very high priority needs to be given to replacing the rapid oxidation (burning) of natural gas and petroleum. Likewise a high priority should be established for liberating oil from oil shale.

6.7 NUCLEAR PLANT SITING

The potential contribution of nuclear power for improving our energy independence is diminished with each delay in siting and licensing a plant. Licensing by the AEC to assure safety and environmental consideration has become a major bottleneck.

It may be timely to separate the two functions of nuclear safety review from site review and approval as proposed by the Atomic Industrial Forum.[15]

The AIF suggestion calls for having a "lead agency" of the government review all site-related matters and for implementing the provisions of the National Environmental Policy Act. When the conditions for site approval are specified the utility can select an approved site and make its application to the AEC. By initiating such action and starting an inventory of approved sites the ten-year lead time could conveivably be reduced to seven years or less.

The reduced time cycle could not do much to improve the critical situation between now and 1982, but could in the decade that follows which will call for the siting of at least twice as many nuclear units. With the situation that already exists in the AEC a doubling of their workload would appear intolerable. It may be logical for WINB to assist in efforts by the states to develop an inventory of approved sites and develop site certification capability. With guidance by WINB and the utilities the state natural resource agencies could perform these tasks. Such assistance should, however, not preclude a utility from developing its own site when schedules permit.

There are more than ample number of potential nuclear plant sites in the West for accommodating all nuclear units needed by 1990. As the 14 units come on line during the next ten years it will be easier for the state natural resource agencies to recognize the minimal impact of a modern nuclear plant.

6.8 REGIONAL ENERGY DEVELOPMENT POLICY

The West has an opportunity to become a net exporter of coal, uranium and oil. How these resources will be developed is the concern of each state, the region and the nation. It would seem that within limits, the states should have the right to manage their own energy resource development. Since the western states are interdependent and interlaced with electric transmission lines it is logical to have a regional development policy.

With regional energy development the national energy development efforts can be simplified and channeled towards supporting research and development on potential domestic energy resources and unlocking the energy reserves held within federal lands throughout the West. Releases are needed on federal lands with geothermal fields, oil shale, coal in the Rockies, and large oil reserves both on-shore and off-shore. For the West to assist the nation in becoming energy independent, these energy reserves under federal land need to be liberated, on a timely basis. Failure of the federal government to grant any new coal leases in the West for over two and a half years is a point of concern by development groups in the mountain states. Continued delays to lease federal lands for geothermal power development is of concern to those that have been ready to begin exploratory drilling for the past two or three years.

Meanwhile the West must act to develop its own energy resources. As noted above, the West has sufficient coal, uranium, oil and gas to be self-sufficient. These are all resources that can be used with developed and engineered systems. The western states need not wait to implement their own plans for energy resources development. The Western Governors recognized this need at the 1973 Western Governor's Conference. Each governor has appointed a senior aide to assist in developing a regional energy plan.

The regional energy plan is initially expected to be more related to energy conservation and mutual assistance than towards resource development. With continued determination the western states can progress in attracting private developments on state and federal lands.

7.0 OBSERVATIONS

The energy situation in the West at the end of 1973 was grim but far from hopeless. The West has the resources, the leadership and the talents to become a net exporter by the end of 1985.

To understand the basis upon which to build a region which is a net exporter in energy a few of the principal observations have been listed below:

(1) The principal electric load centers of the West are along the West Coast.

(2) The trend in energy sources is away from hydroelectric, gas and oil and towards coal and uranium.

(3) Coal production in four western states is beginning to escalate rapidly.

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[15] Resource Needs for Nuclear Power Growth, Atomic Industrial Forum, New York, 1973.

(4) The WINB member states are already net exporters of coal, oil and uranium but are importers of natural gas.

(5) Even at 1971 rates, coal production in the coal-producing states of the West tapped less than 0.05 percent of the minable reserves.

(6) In 1971, California consumed nearly as much energy as all the other western states combined, but is in a good position to receive oil and gas from Alaska.

(7) The net electrical generation resources of the West exceed the projected demand between now and 1982 by a narrow margin.

(8) The extent to which nuclear power will fulfill future electrical energy needs of the West will depend upon site development and improvements in licensing procedure.

(9) The West can become a net exporter of energy before 1985 but probably not before 1980 and will depend upon reducing the projected energy growth rate.

GLOSSARY

Asphalt - A brown to black solid or semisolid bituminous substance occurring in nature.

Barrel - A liquid volume measure equal to 42 U.S. gallons.

Bituminous coal - "Soft coal," coal containing between 15 and 50 percent volatile matter.

Bituminous rock - A rock containing hydrocarbons or bituminous material.

B.O.E. - Barrel of Oil equivalent; a unit of energy equivalent to the energy in a barrel of crude oil or 5,800,000 BTU's.

Breeder reactor - A nuclear reactor that creates more fissionable fuel than it consumes.

Btu - British thermal unit; the amount of heat needed to raise the temperature of one pound of water 1^{o} F. at or near 39.2^{o} F.; a measure of energy.

Coal gasification - The conversion of coal to a gas suitable for use as a fuel.

Condensate - Known sometimes as distillate. A heavier hydrocarbon occurring usually in gas reservoirs of great depth and high pressure.

Conversion factors -

Natural Gas	1,075 BTU per cubic foot
Crude Oil	5,800,000 BTU per barrel
Oil Shale	5,800,000 BTU per barrel of recovered oil
Residual fuel oil	6,300,000 BTU per barrel
Western coal (typical)	20,000,000 BTU per short ton
Wood	216,000 BTU per cubic foot
Kilowatt hour (kwh)	3,412 BTU per kwh (theoretical) 9,895 BTU per kwh (at 34.5% efficiency) .0017 Barrels per kwh

Diesel oil - Fuel used for internal combustion in diesel engines; usually that fraction which distills after kerosine.

Enriched uranium - Uranium in which the amount of the fissionable isotope, uranium-235, has been increased above the 0.7 percent contained in natural uranium.

Fission - The splitting of an atomic nucleus by a subatomic particle (free neutron) to produce a large amount of energy.

Fossil fuel - Any naturally-occurring fuel of an organic nature, such as coal, crude oil, and natural gas.

Fuel cell - A device in which fuel and oxygen are combined to produce chemical energy that is converted directly into electricity.

Fusion - The formation of a heavier nucleus from two lighter ones with the attendant release of a large amount of energy.

Geothermal energy - The heat energy available in the earth's subsurface.

Gross national product (GNP) - The total market value of the goods and services produced by the nation before the deduction of depreciation charges and other allowances for capital consumption; a widely used measure of economic activity.

High-sulfur coal - Generally, coal that contains more than one percent sulfur by weight.

Hydroelectric plant - An electric power plant in which the turbine-generators are driven by falling water.

Jet fuel - Fuel meeting requirements for use in jet engines and aircraft turbine engines, generally of kerosine or naphtha base components.

Kilowatt hour - The amount of energy equal to one kilowatt in one hour; equivalent to 3,412 BTU's.

Kilowatt - One thousand watts.

Liquefied natural gas (LNG) - National gas that has been changed into a liquid by cooling to about -260°F., at which point it occupies about 1/600 of its gaseous volume at normal atmospheric pressure.

Liquefied petroleum gas (LPG) - Propane, butane, or mixture thereof; kept in the liquid state by pressure or refigeration to facilitate handling.

Low sulfur coal and oil - Generally, coal or oil that contains one percent or less of sulfur by weight.

Magnetohydrodynamic (MHD) generator - One that produces electricity by passing hot plasma through a magnetic field.

Mcf. - One thousand cubic feet.

Megawatt (MW) - One thousand kilowatts.

Megawatt-hours (MWh) - One thousand kilowatt-hours.

Naphtha - Liquid hydrocarbon fractions recovered by the distillation of crude petroleum.

Natural gas - Naturally-occurring mixtures of hydrocarbon gases and vapors, the more important of which are methane, ethane, propane, butane, pentane, and hexane.

Nuclear electric powerplant - One in which heat for raising steam is provided by fission rather than combustion of fossil fuels.

Nuclear energy - Energy produced largely in the form of heat during nuclear reactions, which, with conventional generating equipment can be transformed into electric energy.

Nuclear (atomic) fuel - Material containing fissionable materials of such composition and enrichment that when placed in a nuclear reactor will support a self-sustaining fission chain reaction and produce heat in a controlled manner for process use.

Oil shale - A sedimentary rock containing solid organic matter (kerogen) that yields substantial amounts of oil when heated to high temperatures.

Petroleum - A naturally-occurring material (gaseous, liquid, or solid) composed mainly of chemical compounds of carbon and hydrogen.

Quadrillion Btu - 10^{15} (thousand million million) Btu's; equal to the heat value of 965 billion cubic feet of gas, 175 million barrels of oil, or 38 million tons of coal.

Reserves - The amount of a mineral expected to be recovered by present-day techniques and under present economic conditions.

Residual fuel oil - Topped crude petroleum or viscous residuum obtained in refinery operation. (Am. Petroleum Inst. Glossary).

Resources - The estimated total quantity of a mineral in the ground; includes prospective undiscovered reserves.

Secondary recovery - Any method of augmenting the natural energy of a petroleum reservoir to increase production.

Short ton - A unit of weight that equals 20 short hundredweights or 2,000 avoirdupois pounds. Used chiefly in the United States, in Canada, and in the Republic of South Africa. (USBM, Dictionary of mining, mineral, and related terms).

Solar energy - Radiation energy from the sun falling upon the earth's surface.

Steam-electric plant - A plant in which the prime movers (turbines) connected to the generators are driven by steam.

Subbituminous coal - Coal of rank intermediate between lignite and bituminous; weathering and nonagglomerating coal having calorific values in the range 8,300 - 13,000 BTU, calculated on a moist, mineral-matter-free basis. (American Society for Testing Materials, D338-38).

Synthetic liquid fuel - Liquid hydrocarbon material produced from solid carbonaceous material, such as oil shale.

Synthetic natural gas (SNG) - Gas produced from conversion of some carbonaceous material, such as coal, naptha, crude oil, residual oils, etc.

Tar sand - Any sedimentary rock that contains bitumen or other heavy petroleum material that cannot be recovered by conventional petroleum recovery methods.

Thermal plant - A generating plant which uses heat to produce electricity. Such plants may burn coal, gas, oil, or use nuclear energy to produce thermal energy.

Watt - The rate of energy transfer equivalent to one ampere under a pressure of one volt at unity power factor.

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